This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

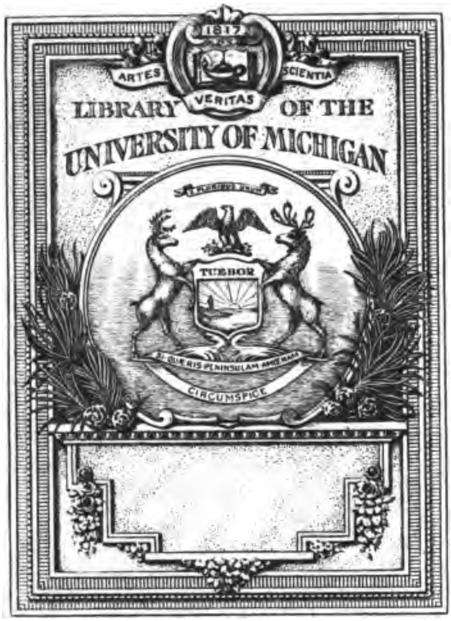
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUÆRIS PENINSULAM AMŒNAM
CIRCUMSPICE

Science Library
QE
363
.K46
v.2

OUTLINES

OF

MINERALOGY.

By J. ohn KIDD, M.D.
PROFESSOR OF CHEMISTRY IN THE UNIVERSITY
OF OXFORD.

VOL. II.

OXFORD:
PRINTED BY N. BLISS,
For J. Parker, and R. Bliss;
Longman, Hurst, Rees, & Orme, and Messrs. Rivingtons,
LONDON.

1809.

Science - Mineralogy
Stechert
12-8-42
46905

5-10-45. HRT.

CONTENTS OF THE SECOND VOLUME.

	Pag.
SALINE SUBSTANCES	1
ALKALINE SALTS	3
Nitrate of Potash	—
Carbonate of Soda	4
Muriate of Soda	7
Borate of Soda	10
Muriate of Ammonia	12
EARTHY SALTS	13
Sulphate of Alumine	—
METALLIC SALTS	20
Sulphate of Iron	—
Sulphate of Copper	23
Sulphate of Zinc	24
INFLAMMABLE SUBSTANCES	27
SULPHUR	30
THE DIAMOND	31
AMBER	36
MELLILITE	39
ON THE CONVERSION OF VEGETABLE MATTER INTO COAL	41
Wood of a Submarine Forest in Lincolnshire	43
Turf	—
Peat	—
Imperfectly Mineralized Leaves	44
Bovey Coal	45
Jet	49

COMMON COAL
Cannel coal
Staffordshire coal
Whitehaven coal
Newcastle coal
Kilkenny coal
Culm of Pembrokeshire
Observations on Coal
PLUMBAGO
BITUMEN
Naphtha
Petroleum
Maltha
Asphaltum
Elastic Bitumen of Derbyshi
RETINASPHALTUM

METALLIC SU

PLATINA
GOLD
Native Gold
On the Separation and R
SILVER
Native Silver
Silver alloyed with Anti
Silver alloyed with Ars
Sulphuret of Silver
Antimoniated Sulphur
Black Silver Ore
Muriate of Silver
QUICKSILVER
Native Quicksilver
Quicksilver alloyed
Sulphuret of Quicks

Pag.
Muriate of Quicksilver . . . 97
COPPER 98
Native Copper . . . . —
Red Oxyd of Copper . . . 101
Earthy Red Oxyd of Copper mixed with Brown Oxyd of Iron 105
Sulphuret of Copper . . . —
Grey Sulphuret of Copper . . . 106
Variegated or Iridescent Sulphuret of Copper 108
Yellow Sulphuret of Copper . . 109
Grey Copper Ore 115
Carbonate of Copper . . . 117
Blue Carbonate of Copper . . . —
Green Carbonate of Copper . . 119
Loose fibrous Green Carbonate of Copper . 121
Compact fibrous Green Carbonate of Copper 122
Earthy Green Carbonate of Copper . 124
Distinctive Marks of the three preceding Varieties 125
Muriate of Copper 126
Phosphate of Copper . . . 127
Arseniate of Copper . . . —
LEAD 129
Native Lead . . . . —
Native Oxyd of Lead . . . —
Sulphuret of Lead 130
Carbonate of Lead . . . 136
Crystallized Carbonate of Lead . . —
Earthy Carbonate of Lead . . . 138
Molybdate of Lead . . . 139
Sulphate of Lead 140
Phosphate of Lead . . . 141
Chromate of Lead 143
Muriate of Lead 145

TIN
- *Native Tin*
- *Native Oxyd of Tin*
- *Sulphuret of Tin*

IRON
- *Native Iron*
- *Native Oxyd of Iron*
- *Magnetic Iron Ore*
- *Specular Iron Ore*
- *Native Red Oxyd of Iron*
- *Hematite*
- *Fibrous Hematite*
- *Earthy Hematite*
- *Brown and Black Hematitic I*
- *Argillaceous Iron Ore*
- *Lowland Iron Ore*
- *Sulphuret of Iron*
- *Spathose or Sparry Iron Or*
- *Phosphate of Iron*
- *The Turquoise*
- *Arseniate of Iron*

ZINC
- *Native Oxyd of Zinc*
- *Sulphuret of Zinc*
- *Carbonate of Zinc*

ANTIMONY
- *Native Antimony*
- *Sulphuret of Antimony*
- *Hydrosulphuret of Anti*

ARSENIC
- *Native Arsenic*
- *Arsenic alloyed with Ir*
- *Sulphuret of Arsenic*

Pag.

Native Realgar 205

Native Orpiment . . . . . —

Cobalt 209

Native Cobalt alloyed with Arsenic . . —

Native Oxyd of Cobalt . . . 210

Arseniate of Cobalt 211

Bismuth 212

Native Bismuth . . . . . —

Native Oxyd of Bismuth . . . . —

Nickel 213

Nickel alloyed with Arsenic . . . —

Native Oxyd of Nickel . . . . —

Manganese 214

Native Oxyd of Manganese . . . . —

White and Rose coloured Ores of Manganese 215

Molybdena 216

Sulphuret of Molybdena . . . —

Chrome 217

Tellurium 218

Uranium 220

Pech-blende . . . . . —

Micaceous Uranite 221

Titanium 222

Native Oxyd of Titanium . . . —

Octohedral Titanite 223

Menachanite 224

Tungsten 225

Tungsten . . . . . —

Wolfram 226

APPENDIX.

ROCKS 1

Granite . . . . . —

	Pag.
Gneiss	4
Micaceous Schistus	5
Porphyry	—
Basalt	6
Basalt of the Giants' Causeway and of Staffa .	7
Ferrilite	15
Trapp	18
Clinkstone	—
Amygdaloid	19
Sienite	20
Grünstein	21
Pebblestone	—
Sandstones	24
Siliceous Pebbles	28
Tripoli	31
Lava	—
Puzzolana	34
Rapillo Nero	35
Trass or Terras	—
Pumice	—
Obsidian	38

SALINE SUBSTANCES.

A SALINE substance, according to the present acceptation of the term, consists of an alkali, or earth, or metallic oxyd, chemically combined with any acid. This definition therefore includes almost all the natural forms of lime, strontian, and baryt; which differ however so materially in their general characters and relations from the minerals commonly denominated salts, and correspond so closely with earths, that I have thought it convenient to class them with the latter substances.

The term salt in the present instance is restricted to those varieties which are remarkable for their taste and solubility in water: but of these there are only a few that can with propriety be introduced into a system of mineralogy; and strictly speaking perhaps only one, which is common salt. This occurs in regular strata: the rest of those salts which are usually admitted into mineralogical systems appear to be merely the result of the decomposition and alteration of other minerals; and might more properly, had not custom determined otherwise, form a part of the history of those substances from which they are derived.

ALKALINE SALTS.

NITRATE OF POTASH.

Common Nitre.

Sal petræ, or *Saltpetre ;* so called from the circumstance of its being often found attached to the walls of buildings.

Its taste is accompanied with a sensation of cold.

Soluble in seven times its weight of cold water; and in nearly its own weight of boiling water.

Specific gravity 1,93.

Primitive form, a rectangular octohedron: the common form is a six-sided prism, two of the opposite sides being rather broader than the other four, terminated by a wedge-shaped pyramid.

Potash	51,8
Nitric Acid . . .	44,0
Water	4,2
	100,0 *Kirw.*

Nitre is found abundantly in the soil of many parts of the world; particularly India: and is periodically regenerated in those situations. Its history in other respects belongs rather to chemistry than to mineralogy.

CARBONATE OF SODA.

Natron; and, occasionally, *Nitrum;* of the early natural historians.

Effervesces upon the addition of any strong acid.

Soluble in twice its weight of cold water; and in rather less than an equal weight of boiling water.

Converts most vegetable blue colours to green; in consequence of the uncombined or unsaturated alkali contained in it.

Has that peculiar taste which is called urinous or alkaline.

Specific gravity 1,35.

Primitive form has not yet been ascertained: it is supposed to be a wedge-shaped octohedron. It commonly crystallizes in the form of a decahedron composed of two four-sided pyramids applied base to base; and having the apex of each truncated. But the native substance is rarely crystallized distinctly, and has generally a confused stalagmitic structure.

Soda	14,42
Carbonic Acid . . .	21,58
Water	64
	100,00 *Kirw.*

To the west of the Delta of Egypt are several lakes, some of which contain common salt or muriate of soda in solution; others, natron or carbonate of soda. In some of these lakes both these substances are contained, and are deposited alternately on the sides of the lake in consequence of the evaporation of the water that held them in solution; this alternate deposition depending on the different degrees of solubility of these salts: the common salt being the least soluble is first crystallized; and when that has been separated to such an extent as to leave a considerable excess of carbonate of soda or natron in solution; then, according to the law observed by Berthollet and alluded to by Mr. Watt in his experiments on ferrilite *, this latter substance begins to crystallize.

Berthollet who attentively examined the situation of these lakes, and the nature of the surrounding country, found that the soil of the neighbourhood was strongly impregnated, partly with carbonate and partly with muriate of soda. He supposes that the natron, or carbonate of soda, is the result of the decomposition of the common salt by means of carbonate of lime; during which process the lime combines with the muriatic acid of the common salt forming with it muriate of lime; while the carbonic acid, thus disengaged from the lime, combines with the soda, and thus forms the natron.

---

* Vid. Append. p. 17.

From what has been said it will be easily imagined that the natron of Egypt constantly contains a proportion of common salt; and that this proportion will be very variable. It is besides mixed with vegetable particles and other accidental impurities which give it the appearance of a mass of common earth.

The terms natron and nitrum, which are used indiscriminately in the works of the early natural historians, are most commonly applicable to the substance at present under consideration; but they are sometimes applicable to saltpetre, the nitre of the present day; and sometimes to sal ammoniac, as it is usually called, which is a chemical saline combination of ammonia, or hartshorn, and muriatic acid. Thus when Pliny in speaking of nitre *(nitrum)* says, "Calce aspersum reddit odorem vehementem *;" he evidently alludes to that pungent smell which is constantly produced by mixing lime with muriate of ammonia; but which cannot be accounted for as proceeding from a mixture of lime and carbonate of soda or natron.

Carbonate of soda may be distinguished from other mineral saline substances, by its effervescence upon the addition of any strong acid; by its alkaline taste; and by the property which it possesses of changing vegetable blue colours to green.

---

* Nat. Hist. vol. vi. p. 326. ed. Brot.

MURIATE OF SODA.

Common salt.

Rock salt; from its occurring in regular strata, and being quarried like common stone.

Sal gem; applied to these varieties of rock salt, which are remarkable for their colour or transparency.

Soluble in about thrice its weight of cold, or hot, water.

Specific gravity 2,12.

Primitive form, a cube.

Soda	38,88
Muriatic acid . . .	53,
Water	8,12
	100,00 *Kirw.*

Common salt very often crystallizes in the form of a hollow four-sided pyramid, made up of numerous squares successively attached to each other and regularly increasing from the apex. An accurate description of the progress of this crystallization is quoted by M. Haüy. It commences by a cube which forms the apex; to the upper edges of which crystalline particles attach themselves, forming as it were a hollow square border: other crystalline particles attach themselves to the outer edges of this border; and by a repetition of the process the form becomes pyramidal.

Extensive strata of common salt occur in various parts of the world, particularly in Europe; mountains of salt are occasionally mentioned by ancient authors.

Rock salt is generally accompanied by gypsum and indurated ochry clay: and is always situated among secondary strata. In some parts of the world it has been employed instead of stone, in building: this use of it is mentioned by Strabo and Pliny.

The rock salt of Cheshire is of a brownish red colour, in consequence of the presence of an ochry clay: this clay is immediately separated by solution and crystallization; subsiding to the bottom of the water in which the salt has been dissolved, and leaving the supernatant liquor clear; from which the salt may be recovered by evaporation of the water that held it in solution, in a perfectly colourless state. Transparent colourless patches of salt occur here and there in the natural stratum; but upon the whole this is of the colour above described, and the appearance of the mine is much the same as of a quarry of common stone of the same colour.

Mr. Playfair describes a peculiarity in the rock salt of Cheshire. He says that the mass is compact, but arranged in nodules of five or six feet diameter: these nodules are not perfectly spherical, but each is compressed by those that surround it, so as to have the shape of an irregular polyhedron.

Pallas speaks of rock salt in the neighbourhood of the river Jaïk, which is sometimes so hard as to snap the pick-axes made use of in quarrying it: he adds that this salt is generally white; often as transparent and colourless as crystal: and that it readily breaks into cubic fragments. He observes that the southern parts of Russia, Siberia, and Grand Tartary, are as rich in common salt as any tract of land in the known world.

Bruce mentions that in some parts of Abyssinia cubic masses of rock salt pass as current coin.

The brine springs met with near Droitwich in Worcestershire, from which a great quantity of salt is separated by the process of evaporation, probably communicate with strata of rock salt: and perhaps these strata may hereafter be discovered; for within the last two or three years a vein of gypsum has been met with in that part of Worcestershire, which alone might lead to the expectation of finding rock salt.

Common salt has been met with of a fibrous structure, in the Tyrol; and in one or two other situations.

A variety of common salt, which may perhaps more properly be called a variety of gypsum, occurs near Halle in the Tyrol: it has the appearance of rock salt; and, though slightly, the taste also: but it is scarcely soluble in water. According to Klaproth its constituent parts are

Sulphate of Lime	57,8
Muriate of Soda	31,2
Carbonate of Lime	11
	100,0

Muriate of soda may be distinguished from all other salts, by its appropriate taste; by its disposition to separate into cubic fragments; and by its decrepitating when thrown on burning coals.

BORATE OF SODA.

Borax: this name occurs in Geber who wrote in the ninth century; and is derived from the word *Baurach*, in use among the Arabians.

Tinkal: this is the name it bears in India, while it is in an impure state.

Melitites lapis, of Pliny? "Melitites lapis succum "remittit dulcem: tusus et cera mixtus faucium "exulcerationi medetur *." These characters apply to borax.

It has the double refracting power in a high degree.

Fusible with effervescence into a transparent glass.

Soluble in twelve times its weight of cold; and six times its weight of warm water.

Phosphorescent, when two pieces of it are struck together.

---

* Nat. Hist. lib. xxxvi.

Has an alkaline taste, with at the same time a degre of sweetness.

Specific gravity 1,74.

Prmitive form, a four-sided prism.

Soda	17
Boracic Acid . . .	39
Water	44
	100 *Bergm.*

This substance has been sometimes mistaken for th *chrysocolla* of Pliny; in consequence no doubt of th use that jewellers commonly make of it in solderin gold. The occasion of the error is curious, and wil be taken notice of in describing the variety of carbonate of copper called malachite.

The origin of borax is not known: it is probabl that it is separated by the process of evaporation fron the water of certain lakes, or extracted by lixiviatio from the soil, in different parts of Persia, and the nort of India. It may be distinguished from alum by it sweeter and less astringent taste; and by not approaching to the cubic or octohedral form so commonly observable in the crystals of the latter substance. It is, besides, the only soluble salt that i converted into a glass by the blowpipe: which property therefore distinguishes it from saline substance in general.

MURIATE OF AMMONIA

Sal Ammoniac; of commerce: the na
from the particular spot in Afric
originally found.

Soluble in about three times its weigh
and in little more than its weig
ter.

Volatilized, without decomposition.

Deliquesces, upon exposure, by
moisture of the atmosphere.

Specific gravity 1,42.

Primitive form, the regular octoh

Ammonia . . . .
Muriatic Acid . . .
Water . . . .

The history of this subst
chemistry than mineralogy.
on the surface of some soil
and it is found in a *sublim*
of Etna and Vesuvius.

EARTHY SALTS.

Sulphate of Alumine.

Alum: in this there is always a small quantity of alkali + necessarily present; because a simple combination of alumine and sulphuric acid, the principal constituent parts of alum, would not crystallize.

Roche alum, or *rock alum:* according to Wallerius, who refers to Leibnitz, this term is derived from *Roçca* in Syria; from whence the method of artificially preparing alum was introduced into Europe about 350 years since. According to Kircher, the district of Tolfa situated about ten miles from the Tyrrhene sea is full of rocks, which, when roasted for twelve or fourteen hours, afford alum by evaporation: and hence the term *rock alum.*

Roman alum: this name, originally applied to the local variety, is now often given to any very pure form of alum.

potash or ammonia, [illegible] [illegible]
[illegible] [illegible]
chrystallize

Alum has a sweetish, but very astringent taste.
Soluble in about twelve times its weight of cold; and in less than in its own weight of boiling water.
Swells with effervescence at a very low red heat.
Specific gravity 1,71.

Sulphate of Alumine . . .	49
Sulphate of Potash . . .	7
Water	44
	100 *Vauq.*

From what has already been said when speaking of aluminous shale, it appears that that variety of slate is capable in many instances of producing alum. Shale of this kind commonly contains that natural combination of iron and sulphur which is called pyrites; or sulphuret of iron. Upon exposure to air the sulphur of the pyrites is often acidified; by decomposition partly perhaps of the air itself, and partly of the moisture contained in it.

Some varieties of sulphuret of iron undergo this alteration more readily than others: but the cause of this has not yet been ascertained. Perhaps in these instances the iron may be in a lower state of oxydation than in those where the change does not take place so readily: at least we might by reasoning infer that the iron would in such a case be disposed to attract oxygen, or the acidifying principle, more readily than in others. And if a convenient and economical method could be discovered of reducing the iron to a lower degree of oxydation, it might perhaps facilitate the natural process.

Perhaps also, in those varieties of shale which undergo this alteration very slowly, the process might be accelerated by sprinkling the mass with water slightly acidulated by sulphuric acid, and containing the proportion of potash requisite for the crystallization of the alum. The expectation of success cannot be considered unreasonable in an experiment of this kind, because there is little doubt that the acid would occasion a commencement of the process: and numerous instances might be mentioned to shew that a small proportion of additional matter will excite, and promote a natural action, which either would not have been excited spontaneously, or would have proceeded by very languid steps.

It is observed that in those varieties of shale which readily undergo the alteration above described, the pyritical matter is in a very minute state of division, and very uniformly disseminated through the mass: and from the observation of M. Klaproth * it appears probable that the formation of the acid does not necessarily depend upon the presence of pyritical matter; but that in some instances the sulphur, from whence the acid is derived, is united with the coaly matter present in the shale.

---

* Vid. vol. i. p. 190.

Kircher in describing the art
alum, says, that the fragments of
first roasted; and then heaped
and exposed to the sun: afte
a month, they are affused fou
water, which disintegrates
kind of argillaceous paste.
drons and boiled; and the
drawn, and made to cryst
to the manufacturer.

As iron is always pres
tion in aluminous shale
combines with that met
forms of alum contain
bination of the acid w
tallic salt commonly
the presence of this
green colour of nat

It happens that
alum is derived
scarcely contains
the absence of th
been extended t
says that Rom
white aluminou
ritory of Civit

The Hurle
tioned in the

minous shale, in which the different stages of the formation of the alum may be traced by the most delicate steps. One of the proprietors has liberally presented, to the mineralogical collection at Oxford, a series of specimens illustrative of the gradual formation of the alum; a description of which will not be, perhaps, unacceptable.

The *first* specimen in the series is a portion of the natural rock, of a uniform brownish black colour: its schistose structure is scarcely visible even when it is examined with attention; but it is easily separable into laminæ, not however of a uniform thickness, by mechanical means.

The *second* very distinctly exhibits the schistose structure: the laminæ are separated from each other by a distance equal to their own thickness, which is about the twelfth of an inch; and between the laminæ, and at right angles to them, are numerous semitransparent filaments of a silky lustre, which adhere to the surfaces of the laminæ between which they are placed. In their appearance and size these fibres are very like the substance called silk-worm gut, employed in making fishing lines. The fibres are so numerous as often nearly to touch each other.

The *third* specimen scarcely differs from the second; but represents the same appearances in a more remarkable manner: here and there the fibres are so

clos
unsp
an
I
is i
dist
spe
cor
col

st
fic
a
ir

c
a
l

duces a black colour when added to the infusion of oak-bark, or gall-nut. It may also by the eye be mistaken for fibrous gypsum, or for amianthus; but may at once be distinguished from these by its taste and solubility.

METALLIC SALTS.

SULPHATE OF IRON.

Green vitriol; from its general colour and glassy appearance.

Martial vitriol; or *vitriol of iron.*

Chalcanthum, and *flos æris;* of the early natural historians. The terms χάλκος and *æs* arose from the brass yellow colour of those natural forms of iron, from which the substance called chalcanthum and flos æris were obtained.

Green copperas.

Soluble in twice its weight of cold; and somewhat less than its weight of boiling water.

Has the same taste with ink; which indeed owes its peculiar taste to the presence of sulphate of iron.

Has a double refracting power.

Produces a black colour when mixed with infusions of vegetable astringent substances.

Specific gravity 1,83.

Primitive form, an acute rhomboid; the plane angles of which are 100d 10′ and 79d 50′.

Oxyd of Iron . . .	28
Sulphuric Acid . .	26
Water	46
	100 *Kirw.*

The natural history of sulphate of iron is necessarily contained, in a great measure, in that of alum. The alum is formed in consequence of the acidification of the sulphur of the pyrites contained in aluminous schist; the acid uniting with the alumine of the shale in the moment of its formation. If you suppose a similar process to take place in insulated masses of sulphuret of iron, where no clay is present, the acid would unite with the metallic substance simply; and the salt in question would be formed. This process often does take place naturally; particularly in pyrites of a radiated structure, and globular form. Sometimes it is accelerated or even produced by artificial means, as by roasting the pyrites; and subsequently submitting it to the treatment described above, under the head of sulphate of alumine.

In the spontaneous formation of sulphate of iron, the pyrites first loses its splendour: then swells and separates into numerous fissures. After this its surface is partially covered with a white efflorescing powder, which is the *flos æris* of Pliny. If this be separated by lixiviation, and the lixivium be evaporated, crystals of green vitriol will be obtained.

In some instances green vitriol is formed in the

the substance of aluminous shale together with alum; and communicates to the latter a considerable shade of green.

In the shale that overhangs the Odin mine, at Castleton in Derbyshire, I some years ago found very accurately defined rhomboidal crystals of a green colour; which, judging from their form and colour, were probably almost a pure natural form of sulphate of iron. These crystals were situated between the laminæ of the shale in considerable number, but distinct from each other. The appearance was very striking; and does not, I believe, often occur.

Green vitriol by exposure becomes yellow, and at last brown: in this state perhaps it answers to the *misy* and *sory* of Pliny.

The *melanteria* or ink-stone of Pliny seems to be a variety of sulphate of iron that has been formed in a matrix containing vegetable astringent matter, which uniting with the metallic salt has produced a natural ink.

Sulphate of iron may be distinguished from all other salts, either by its colour; or, if this is not present, by the property it possesses of producing a black colour when mixed with vegetable astringent matter.

Sulphate of Copper.

Blue vitriol; from its colour and glassy appearance.
Vitriol of copper.
Blue copperas.
Soluble in four times its weight of cold, and twice its weight of boiling water.
Has a strong styptic taste.
Colour, a deep blue.
Specific gravity 2,19.
Primitive form, an irregular obliquely angled parallelepiped.

Oxyd of Copper	40
Sulphuric Acid	31
Water	29
	100 *Kirw.*

The history of sulphate of copper is naturally connected with that of sulphate of iron; this salt being formed from the sulphuret of copper, or copper pyrites, by a process exactly analogous to that by which sulphate of iron is formed from sulphate of iron or iron pyrites: and as in almost every instance copper pyrites contains some portion of iron, sulphate of copper, or blue vitriol, generally contains some portion of sulphate of iron, or green vitriol: and hence in the blue vitriol of commerce it is very usual to find particles of green vitriol: hence also that confusion which occurs in the descriptions of these two substances in the works of the early natural historians.

Sulphate of copper is not nearly so often the result of a spontaneous alteration of copper pyrites, as sulphate of iron is of iron pyrites. Sometimes it is held in solution in the water that drains from mines of sulphuret of copper: but it is in most instances obtained by the artificial process already described under the head of sulphate of iron. Pliny gives an accurate description of this process, and says that the substance when crystallized resembles glass.

Sulphate of copper may easily be distinguished from most other minerals by its blue colour: some other natural forms of copper are also blue, but they are not soluble in water.

SULPHATE OF ZINC.

White vitriol.
White copperas.

Soluble in a little more than twice its weight of cold; and in a much less proportion of boiling water.

Has a strong styptic taste.

It is colourless, when pure; when it contains any considerable proportion of iron it is of a light greenish yellow.

Specific gravity, when pure, is 1,91.

Primitive form, not known. The common form of its crystals is a flat four-sided pyramid, terminated at each extremity by a four-sided or six-sided pyramid.

Oxyd of Zinc	40
Sulphuric Acid . . .	20,5
Water	39,5
	100,0 *Kirw.*

This substance is obtained by artificial processes from the ore of zinc called blende or sulphuret of zinc; much in the same manner as sulphate of iron or of copper, from iron or copper pyrites. It is very rarely formed by the spontaneous alteration of blende.

As in almost every instance blende contains some portion of iron, the white vitriol of commerce, unless subsequently purified, necessarily contains a correspondent proportion of green vitriol; and hence its occasional greenish yellow colour.

INFLAMMABLE SUBSTANCES.

Those substances which are called inflammable are not all capable of producing flame: some simply become red hot when exposed to the necessary degree of heat; and insensibly consume without the phenomena that usually attend the process of combustion.

If exposed to a red heat in a vessel from which atmospherical air is excluded, they are in many instances decomposed; and at the same time their elementary constituent principles form either new, or differently modified, compounds: these are for the most part volatile, and pass away in the form of water, and of oil or bitumen, and different aëriform fluids. That which remains in the vessel consists of earthy and metallic matter, and charcoal. If this residuum be exposed to a red heat in the open air, the charcoal combines with the oxygen or pure part of the atmosphere, and forms carbonic acid gas, or fixed air; which is dissipated, leaving only the earthy and metallic matter. This process has from the nature of it been called "*destructive* distillation;" of all the results of which, the different earths are often the only constituent parts that originally existed in their present form: these are consequently called *educts*; the others, *products*, of the analysis.

The products of the analysis of inflammable minerals are for the most part

Inflammable air, or hydrogen gas.
Heavy inflammable air, or carbonated hydrogen gas.
Fixed air, or carbonic acid gas.
Water.
Oil, or bitumen.
Charcoal.

These substances appear to be ultimately derived from the following elementary principles:

Carbon; or, the base of charcoal.
Oxygen; or, that part of atmospherical air which supports combustion; called oxygen, because it appears to be the acidifying principle.
Hydrogen; or, the inflammable principle; called Hydrogen, because when united with oxygen it constitutes water.

And they severally appear to consist

Inflammable air,	of hydrogen in an aëriform state.
Heavy inflamm. air,	hydrogen & carbon
Fixed air,	carbon & oxygen
Water,	hydrogen & oxygen
Oil or bitumen,	hydrogen carbon & oxygen
Charcoal,	carbon & oxygen

In giving an account of the analysis of inflammable minerals, the aëriform substances will be classed together, under the term "mixed gas."

SULPHUR.

It has the double refracting property to a very high degree.

Acquires the resinous or negative electricity by friction.

Specific gravity 2.

Primitive form, an octohedron, each surface of which is a scalene triangle.

Sulphur is very commonly accompanied by rock salt, or gypsum, or both. Thus, in Sicily, sulphur is found alternating with beds of gypsum: in other places it is found in a matrix of gypsum in the neighbourhood of rock salt. Crystallized sulphur is occasionally met with in the cavities of calcareous or siliceous nodules. It is also found in the apertures of many volcanoes.

The appearance of the flame, and the pungent odour that proceeds from burning sulphur, sufficiently distinguish it from all other substances.

THE DIAMOND.

Adamas; of Pliny, and other natural historians: but the term is occasionally applied to iron and other hard substances.

Opalus and Pæderos; of Pliny?

It is the hardest substance in nature.

It acquires the vitreous or positive electricity by friction.

When pulverized it is of a grey or blackish colour.

It is entirely dissipated by combustion.

It is met with of various colours; pink, orange, yellow, green, blue, and blackish.

Specific gravity varies from 3,51 to 3,55.

Primitive form, the regular octohedron.

By absorption of oxygen it is entirely converted into carbonic acid gas, or fixed air.

Some mineralogists still class the diamond among the precious stones, on account of its general external characters: but as it may be entirely dissipated by exposure to the joint action of heat and air, and affords the same product as the combustion of charcoal, it is now very generally considered as an inflammable body;

and the purest form of carbon, or the base of coaly matter in general.

I shall beg leave to transcribe the passages which seem to render it probable that the *opalus* and its variety the *pæderos* of Pliny are applicable to the diamond of the present day.

Speaking of beryls he says, " plurimum ab iis diffe-
" runt *opali*, smaragdis tamen cedentes. India sola et
" horum est mater. Est in iis carbunculi tenuior ignis,
" est amethysti fulgens purpura, est smaragdi virens
" mare; et cuncta pariter incredibili mixtura lucen-
" tia *." So far the description is perhaps as applicable to the opal as the diamond: but in speaking of the size of the substance he is decribing he says, " Mag-
" nitudo nucem avellanam æquat, insigni apud nos
" historia;" which he then relates: but this description seems applicable to a substance in an insulated state, in which the diamond is often found, or at least may be readily obtained; rather than to a substance so interwoven with and inseparable from its matrix as the opal. But the strongest presumption in favour of the opinion above advanced, arises from what follows; where he is speaking of the adulterated forms of the substance in question, and describing the means of detecting these: " Experimentum in sole *tantum.*
" *Falsis* enim *contra radios* libratis, digito ac pol-
" lice, unus atque idem translucet colos in se con-

---

* Nat. Hist. lib. xxxvii.

" sumptus. *Veri* fulgor subinde *variat*, et plus huc
" illucque *spargit*, et fulgor lucis *in digitos funditur.*
" Hanc gemmam propter eximiam gratiam plerique
" appellavere *pæderota* *."

The method of examining the substance by holding it between the finger and thumb, against the sun's rays; the uniform transparency of the spurious gem; the varying and scattered lustre of the true gem, described as impinging against the fingers of the person holding it; all these characters seem so closely applicable to the diamond, and the diamond alone, that I think they may be admitted as descriptive of that gem.

The Grand Duke of Tuscany was the first person who ascertained that the diamond might be dissipated by the joint action of heat and air: his experiments were conducted at Florence, in the year 1694, by means of a burning glass. The emperor Francis I. repeated the same experiment on the diamond, making use of the heat of a furnace: the experiment was made at Vienna; and here also the diamonds employed on the occasion were entirely dissipated by the action of the fire.

But before the experiments of either of these princes, Sir Isaac Newton having observed that the refractive power of transparent substances was, in general, in proportion to their density; but that of substances of equal density those which were inflammable possessed the refractive power in a higher degree than those which were not; concluded, from a comparison of the density and refractive power of the diamond, that it contained an inflammable principle. From the same mode of reasoning he drew the same conclusion respecting the nature of water. These opinions have since been fully confirmed: with respect to the diamond, by the experiments above related; and, apparently, with respect to water by the experiments of M. Lavoisier.

---

* Nat. Hist. lib. xxxvii.

According to Tavernier diamonds are found in the veins of a sandstone in the Carnatic. M. Haüy says that they are found in Golconda, and other districts of that part of Asia, irregularly imbedded in an ochry earth, of a yellow, orange, or red colour; at the foot of high mountains, consisting in part of quartz.

About the year 1730, diamonds were discovered in Brasil; in an ochry earth, not unlike that in which they are found in India.

Some of the natural crystals of the diamond have convex surfaces, or even approach to a spheroidal form: but this is the natural form of the crystal, and not the effect of attrition. Diamonds indeed can but rarely acquire a rounded or pebble form: because, being harder than all other substances, they cannot be rounded except by mutual attrition, and they seldom are accumulated in sufficient abundance for this.

The unpolished diamond may be distinguished from the varieties of sapphire, from the hyacinth, and from quartz, &c. in acquiring the vitreous or positive electricity by friction; whereas those substances acquire the resinous or negative: from the spinell, by its superior hardness.

AMBER.

Electrum, of Pliny, &c.; from its resemblance in colour to the metallic alloy of the ancients, which consisted of gold and silver, and was called by the same name: or from 'Ηλέκτωρ, one of the names of the sun.

Succinum; from the word ***succus***, under the idea that amber was some inspissated juice. "Arboris "succum esse prisci nostri credidere, ob id suc"cinum appellantes *."

Amber varies from a pale yellow to a brownish orange colour.

The electric property of amber must be familiar to every one. It is the substance in which the property was first discovered, and the term electricity has been derived from one of its synonyms.

When triturated or burnt it emits a peculiar and slightly aromatic odour.

Specific gravity varies from 1,07 to 1,08.

---

* Plin. Nat. Hist. vol. vi. p. 266. ed. Brot.

The appearances and electric property of amber are so often alluded to in ancient authors, that it is not necessary to shew by quotations that they were familiar with the substance: and though the history of its origin is much involved in fable, yet they seem to have had some idea that it was found in the north of Europe.

> —— Κελτοὶ δ' ἐπὶ βάξιν ἔθεντο
> Ὡς ἄρ' Ἀπόλλωνος τάδε δάκρυα Λητοΐδαο
> Ἐμφέρεται δίναις, ἅτε μυρία χεῦε πάροιθεν,
> Ἦμος Ὑπερβορέων ἱερὸν γένος εἰσαφίκανεν[*].

Pliny says, in speaking of amber, "certum est gigni "in insulis septentrionalis oceani[†]:" and, in another place, "ab adverso (Britanniarum) in Germanicum "mare sparsæ Glessariæ (insulæ); quas Electridas "Græci recentiores appellavere, quod ibi Electrum "nasceretur[‡]." In another part he says that in the spring time it was washed on a part of the coast of Germany, from an island in the north sea; concluding with these words, "incolas pro ligno ad ignem uti eo, proximisque "Teutonis vendere[§]." From the foregoing passages it seems very probable that the opinion of Solinus respecting the origin of amber is correct. He says that it was originally brought from the northern sea, through Pannonia and Illyria, into the country bordering on the river Po: and hence Phaeton's sisters, or the poplars of that river, are fabled to have wept amber: this substance being easily mistaken for a vegetable gum.

---

[*] Apoll. Rhod. lib. iv. lin. 611—614.

[†] Nat. Hist. vol. vi. p. 266. ed. Brot.

[‡] Nat. Hist. lib. iii. [§] Ibid. lib. xxxvii.

Amber is found in considerable abundance on the southern shore of the Baltic, accompanied by pebbles and fossile wood, at some depth beneath the surface. It has also been met with in other parts of the world in sand or clay, or in coal mines. The insects visible in many specimens of amber sufficiently prove that it was once in a fluid state: but specimens of this kind are not always natural; at least if it is correctly asserted, that the art of softening amber, and introducing extraneous substances, is sometimes practised.

Amber is distinguished from the singular mineral called mellilite in possessing the electric property to a much more remarkable extent: besides which, mellilite has a double refracting property, which amber has not.

Amber may be distinguished from gum copal, which it often closely resembles, by the following mark: gum copal, during its combustion, is constantly falling in drops; which amber does not.

MELLILITE.

Honey-stone; from its colour.

Crystallized amber; from its form and colour.

Easily cut by the knife.

When pure it acquires the resinous or negative electricity by friction; but only in a slight degree.

In the fire it becomes white, and loses its transparency.

Has a double refracting power.

Specific gravity varies from 1,58 to 1,66.

Primitive form, an octohedron; the common base of the two pyramids, making the octohedron, is a square.

Alumine	16
A peculiar Acid . .	46
Water	38
	100 *Klapr.*

o

This substance has been found at Artern, in Thuringia, in a stratum of fossile wood: and in Switzerland, accompanied by asphaltum. It has not been long discovered. M. Werner first took notice of it; and gave it its present name.

It is not liable to be confounded with any mineral except amber; under the head of which the distinctive marks of the two substances have been already given.

ON THE CONVERSION

OF

VEGETABLE MATTER

INTO

COAL.

IN many situations, and particularly if exposed to stagnant moisture, vegetable matter undergoes a gradual change by which not only its form is altered, but its constituent principles are ultimately destroyed. In this state it is said to be *mineralized.*

The most important tests of the vegetable character, with reference to this change, are the presence of the substances called *extract*, *resin*, and *fibre.*

If vegetable matter be boiled in water; and the water, after having been strained or filtered, be exposed for some time to the open air, a flocculent precipitate takes place from every part of the liquor; which soon subsides to the bottom of the vessel containing it. This is the *extract;* altered indeed by exposure, and now no longer soluble in water: the change is supposed to depend on the absorption of oxygen; and if, by any means, the proportion of oxygen be increased, the extract gradually becomes of a darker colour; blackens; and approaches to the state of charred wood.

If vegetable matter be boiled in rectified spirit of wine, and water be added to the filtered liquor, a white precipitate commonly takes place; which if collected and examined will be found to possess those properties which constitute what is called a *resin*.

By these means then the presence of *extract* and of *resin* may be ascertained: the existence of *fibre*, the last of the three tests of the vegetable character above mentioned, may be ascertained by the eye, and by mechanical division.

The present occasion does not require a minute detail of the process by which vegetable matter is thus mineralized; nor of the arguments by which the nature of this process is established. It will be sufficient to state that, from the ingenious and elaborate experiments of Mr. Hatchett, it very satisfactorily appears, that during the change which vegetables undergo in the situations above alluded to, their extractive and resinous particles gradually disappear, and they are proportionally impregnated with bitumen: and that their fibre blackens; approaches to the character of charred wood; and is gradually obliterated.

The extract is the principle, the traces of which first disappear; the resin, next; the fibre, last: and when every mark of organization has been lost in consequence of the destruction of the fibre, the substance is commonly of a compact texture; and, when broken, presents conchoidal surfaces like pitch. In this state it may be properly called Coal.

The following varieties of mineralized vegetable substances are arranged, as nearly as possible, according to the progress of the change which has been just described.

Wood of a Submarine Forest in Lincolnshire.

Mr. Hatchett in making some experiments on the wood of a submerged forest, at Sutton, on the coast of Lincolnshire, found that its ashes afforded alkali: and as from all the circumstances of its history, it appears that this wood has scarcely undergone any change in its vegetable character; he infers, that mere submersion is not sufficient to destroy the alkali of a vegetable, unless it has at the same time been more or less converted into coal.

Turf.

The roots and stalks of vegetables, growing on heaths and morasses, commonly undergo that spontaneous alteration which has been already described; and this process continuing to take place upon fresh vegetables, the accumulated mass becomes of a considerable thickness; and is then commonly made use of as fuel, under the name of *turf.*

Peat.

In examining turf in its native situation, it will be seen, that in proportion as it is further removed from the surface, the form of the roots and fibres becomes less distinct; until the whole appears like a compact slimy mass of a black colour: in which state it is called *peat*. This substance is used very extensively for fuel in many parts of Europe: being first cut into separate pieces of about the size and shape of a brick, and then dried.

The unpleasant smell occasioned by the combustion of turf, and peat, arises partly from the bitumen, and partly from the decayed vegetable matter mixed with it.

Imperfectly Mineralized Leaves of a schistus from Iceland.

The following account has been extracted from a paper of Mr. Hatchett's in the Philosophical Transactions for 1804: the whole of which is extremely interesting and important; as indeed might be expected from such a quarter.

Mr. Hatchett analysed a variety of schistus, the stratum of which was found by Sir Joseph Banks near Reykum, one of the great spouting hot springs of Iceland. The schistus, which is easily divisible, consists in a great measure of leaves interposed between its laminæ: the form of the leaves and the arrangement of the fibres are distinctly visible; but the substance is apparently half charred. From several circumstances Mr. Hatchett conjectured that the substance was not complete charcoal, and that the vegetable matter was in an incipient state of carbonization; and found, by experiments instituted for the purpose, that 250 grains of the schistus afforded about three grains of *extract*, and one grain of *resin:* the remaining 247 grains, submitted to the process of destructive distillation, gave the following results:

Water	42,50
Thick brown oily Bitumen	7,50
Mixed Gas *	23,75
Charcoal	54,25
Silex	98
Alumine	15
Oxyd of Iron	6
	247,00

The charcoal when burnt afforded no trace of any alkali.

Bovey Coal.

The nature of the stratum, in which the Bovey coal is found, has been already described in the preceding volume †. The substance so called consists of the branches, trunks, and roots of trees that have, to a greater or less extent in different parts, undergone that alteration by which the vegetable principles are charred, and converted into bitumen.

Bovey coal is analogous to the *surturbrand* of Iceland; the *piligno* of the Italians; and the several varieties of bituminous wood, sometimes called *legnite*, met with in different parts of Europe.

---

* Vid. p. 29. † P. 167. 168.

The general appearance of Bovey coal, and the alluvial character of the spot where it is found, sufficiently manifest its origin; and shew that the alteration it has undergone depended on a process analogous to that which takes place in the formation of turf and peat. Some specimens have been lately sent to the museum at Oxford, which have every appearance of the recent vegetable: they appear to have belonged to that part of the trunk which is contiguous to the root; and are of the character of a species of fir. I understand from a gentleman who is thoroughly acquainted with all that part of Devonshire, that the strata of Bovey coal originate from a part of the heath where numerous stumps and roots of trees are remaining: that from this point the strata gently dip, or incline downwards beneath the surface; so that, in proportion as you advance from the roots just mentioned, the accumulation of alluvial matter above the coal becomes thicker. The Bovey coal appears therefore to be the broken trunks and branches of the roots and stumps just mentioned.

From the completely vegetable appearance of the specimens above mentioned, the Bovey coal may be traced by insensible gradations into a state in which every feature of the vegetable is lost, and the substance in colour and lustre and fracture completely resembles pitch. In one part of the heath I met with a few small pieces that exactly resembled common charcoal, but were more easily divisible and almost crumbled between the fingers. I did not submit these to a chemical examination; but I found that when they were employed for the purpose of completing the galvanic circle, no spark was produced; whereas in the case of common charcoal a spark is produced.

In some instances the Bovey coal is obtained in the form of straight flat pieces, three or four feet in length, resembling boards: in which state it is called *board* coal. This flattened form of substances originally cylindrical, as the trunks and branches of trees, is observable in the surturbrand or bituminous wood of Iceland, as well as in the Bovey coal; and also in other similar situations: and the observation extends to all organic remains met with in strata of clay or argillaceous schist: for these are constantly of a flattened form, even in the case of bone and shells: so that the same substances, which in a calcareous stratum preserve for instance their original cylindrical figure, in a stratum of argillaceous schistus are compressed into a plane triangular surface. Bergman, who has remarked the fact, observes that this effect cannot be attributed to mere pressure; because it sometimes occurs in schisti, lying over a calcareous stratum: in which case, as the pressure must necessarily have been greatest upon the lowest stratum, the form of the substance contained in that ought to have been more altered than in the other; whereas the contrary happens. He supposes therefore that the compression of these substances depended in part upon their having been previously softened by incipient putrefaction: and this reasoning Mr. Hatchett observes is applicable probably to vegetable matter; but not to such substances as shells. Mr. Hatchett thinks it therefore probable that this alteration of form has been in a great measure produced by a powerful mechanical action, exerted by the contraction of the argillaceous strata in consequence of desiccation; and that in the case of vegetable matter this force may have been aided by a change in their solidity, as supposed by Bergman; and by the pressure of the superincumbent strata.

The analysis of 200 grains of Bovey coal, conducted in the manner already described *, gave the following results:

Water	60
Thick brown oily Bitumen	21
Charcoal	90
Mixed Gas †	29
	200

By combustion of the charcoal obtained in this ana-

---

* Vid. p. 27. † Vid. p. 29.

lysis four grains of yellowish ashes were left, consisting of silex, alumine, and oxyd of iron ; derived most probably from the earthy matter in which the Bovey coal is imbedded: but there was not the smallest trace of any alkali.

Jet.

Gagates lapis, of Pliny; according to the commonly received opinion.

Black amber; of some mineralogists.

Sufficiently hard to be turned in a lathe.

Specific gravity 1,25.

It is electric; but slightly, and with difficulty.

Wallerius, together with many others, classes this among simple bituminous substances, as a species of asphaltum: but the substance commonly called jet does not emit that strong smell upon being rubbed or heated, which is emitted from asphaltum; nor has it the brittleness of the latter substance: and lastly, it does not swell up and melt, when set on fire, as asphaltum does.

Some specimens of jet have evidently traces of a fibrous texture; and from all the circumstances of its history it appears to be a variety of mineralized wood in which the proportion of bitumen is not very great.

It is met with in the neighbourhood of coal, in detached nodular masses.

It is principally employed for ornamental purposes; as in making beads and buttons, &c.

COMMON COAL.

Carbo fossilis.
Lithanthrax or *stone-coal.*

The natural transition of vegetable matter into a substance completely resembling coal, both in external and chemical characters, may be traced by the most gradual and satisfactory steps. A similar conversion of the one into the other may be effected also by artificial processes: and I have seen specimens, the results of Mr. Hatchett's interesting experiments, which in their appearance so closely resembled common coal, that no eye however experienced could detect the difference; although the difference between their present and their original form was much greater than between that of common coal and vegetable matter in general: this will be readily admitted upon stating that some of the specimens in question were nothing more than an altered state of colourless vegetable oils.

There is no absurdity therefore in supposing that coal in general may have been derived from the gradual alteration of vegetable matter.

In almost all the coal indeed of Staffordshire and the inland counties, as also in the coal of Monmouthshire and Glamorganshire, the traces of a vegetable origin are so obvious; that those even who are ignorant of the foregoing facts, and totally unprepared or even absolutely indisposed to admit this close relation between the mineral and vegetable kingdoms, must be convinced, from the mere appearance, that there is the strongest ground for believing the coal in question to have been derived from vegetable matter.

In speaking therefore of the different varieties of coal, I shall do little more than state their peculiar characters, the names of the places from whence they come, and the results of their chemical analysis; concluding with a few observations illustrative of their general history.

Cannel Coal.

This coal easily catches fire, and burns with a bright flame like that of a candle; from which circumstance it has obtained its name: *cannel* being the common pronunciation of *candle*, in Scotland, and in the north of England.

It has a broad laminated structure; but if broken transversely to the laminæ it exhibits undulating conchoidal surfaces.

Does not stain the fingers.

Burns without caking.

Specific gravity varies from 1,23 to 1,27.

Charcoal	75,20
Bitumen	21,68
Ashes, consisting principally of Alumine and Silex	3,12
	100,00 *Kirw.*

In some places this is called *parrot coal;* perhaps from the crackling noise that takes place during the time that it is kindling. The same term is applied to a spurious kind of coal that contains much earthy matter, and does not burn readily.

Cannel coal does not appear to differ much in any of its characters from jet.

Staffordshire Coal.

Most of the coal that is used in and about Oxford is brought from different parts of Staffordshire. It is in general of a distinctly schistose structure; the laminæ often not more than a quarter of an inch thick. When broken transversely this structure is very distinct; and the cross fracture of the laminæ exhibits a compact texture, with a lustre like that of pitch. If broken in the direction of its laminæ, the surfaces of these appear to be overspread with numerous flattened pieces of charred fibrous wood, lying in various directions. Sometimes these surfaces are continued to a considerable extent; forming an area of several square inches: and here and there the charred appearance is incomplete, and the substance resembles those specimens of Bovey coal in which the vegetable character is not yet destroyed.

Different varieties of the coal under consideration burn with different appearances and results: some of them cake to a hard cinder; others burn away, almost like common charcoal, to light white ashes, containing a very small proportion of earthy matter: in other instances the ashes are in great abundance, and of a dark brownish red colour; in which case the coal is found to contain an unusually great proportion of pyritical matter, or iron combined with sulphur. The sulphur is dissipated during the combustion: the iron is oxydated to a higher degree than it was before; and hence that reddish brown colour.

Now and then pieces are met with partly corresponding with the general external characters of this kind, and partly resembling cannel coal: but the two varieties are perfectly distinct, without any appearance of one graduating into the other.

Some parts of the coal appear to be little more than a mass of earth or stone, generally of a schistose character; slightly penetrated, but little more than coloured, by the coaly matter.

Whitehaven Coal.

Specific gravity 1,25.

It is disposed to separate into quadrangular fragments.

Burns with a clear flame at first; and afterwards cakes.

Charcoal	57
Bitumen	41,3
Ashes	1,7
	100,0 *Kirw.*

Newcastle Coal.

Mr. Kirwan considers this as nearly allied to the Whitehaven coal; and says that, according to the experiments of the Bishop of Landaff, its constituent parts are

Charcoal	58
Bitumen	40
Earthy and Metallic Matter, and Sulphur .	2
	100

Kilkenny Coal.

This variety has a lustre almost metallic.

Specific gravity 1,52.

Charcoal . .	97,3
Ashes . . .	2,7
	100,0 *Kirw.*

This coal does not bur
and then consumes slowly
flame or smoke: this is ac
taining any particle of bit

Culm of P

This is a species of co
resembling the foregoing
verized state; and is not
viously been made up in

Observa

It appears from var
constituent parts are in
charcoal, bitumen, and
matter, &c. constituting
poses that the bitumen
ferent instances; and
phaltum it communic
caking.

Some varieties of
portion of pyrites, wh
in the form of scales

Cavities sometime
which are set with cr

The iridescent ap
the surface of coal
plained.

Coal strata occur

and in the north of France than any other part o
Europe; and are generally accompanied by varietie
of sandstone and bituminous schistus; more rarely b
limestone.

These adjoining strata, as well as the coal itself, usually contain vegetable organic remains.

Brogniart, in speaking of the coal mines near Liege, says that three and twenty different strata have been there met with one below the other; and that they are incurvated in a variety of directions.

It has already been said that the evidences in favour of the vegetable origin of coal are very strong: but the situations in which the coal strata are found, and most of the circumstances connected with their geological history, present such perplexing appearances; that it seems impossible to expect a consistent explanation of the manner in which the accumulation of these masses originally took place.

PLUMBAGO.

Black lead, of which common pencils are made: so called from its dark colour and leaden lustre.

Graphite; from the use to which it is generally applied.

Carburet of iron; from its component parts, carbon and iron.

Specific gravity varies from 2,08 to 2,24.

It is almost entirely volatilized by the continued application of the blowpipe.

Carbon . . .	90,9	
Iron	9,1	
	100,0	*Berthollet.*

Plumbago, which is so called from its resemblance to lead, is met with in different parts of Europe; but occurs in its purest state in Cumberland. The matrix of the Cumberland plumbago, judging from the few specimens I have seen, has the mixed character of a decaying basalt and serpentine.

This substance is by M. Haüy classed among the ores of iron. According to its analysis it corresponds very closely with Kilkenny coal.

Some varieties of it are pulverulent, though th particles easily cohere by slight pressure, and hav a mixed unctuous and metallic lustre. This form o plumbago is much used for rubbing over the surface of stoves, &c. in order to prevent them from rusting also to prevent friction in wheels and other parts o heavy machinery.

Plumbago very closely resembles the metallic ore called sulphuret of molybdena; but if both be rubbed on a piece of white porcelain, it will be seen that the streak made by the plumbago is of the same colour with the substance by which it was made; while that made by the molybdena has a distinctly green shade. It may be distinguished from black crayon by the difference of the streaks made by the two substances on paper: the colour of that made by black crayon is a deep dull black; that of plumbago has somewhat of a metallic lustre.

BITUMEN.

SOME of the products resulting from the distillation of common coal very closely resemble the bituminous substances called naphtha, petroleum, and asphaltum. If therefore you suppose a distillation of coal to be going on in the interior of the earth, the production of the different natural forms of bitumen may thus be accounted for: as also the existence of that variety of coal, to which Culm and Kilkenny coal belong; which, by the distillation here supposed, may have been deprived of their bitumen.

No stress is intended to be laid on this hypothesis further than as it serves for the convenience of arrangement: for thus having traced the formation of bitumen through its various stages, and shewn, in some instances at least, its necessary connexion with vegetable matter, we seem enabled to account for its presence in a separate and insulated state.

Naphtha.

Bitumen fluidissimum, levissimum; Naphtha; of Wallerius.

Pure petroleum.

The following characters are applicable to the naphtha of Modena.

When pure it is nearly colourless.

It has a pungent but not unpleasant smell.

Easily catches fire, and burns with a light flame; leaving scarcely any residuum.

Specific gravity 0,708.

Naphtha is met with abundantly in Persia; and is found issuing from rocks and clays. It has also been found, according to Mr. Kirwan, from whom the foregoing account is taken, at Mont Festin, near Modena.

The specific gravity of naphtha is even less than that of the most highly rectified spirit of wine. By exposure it loses its transparency and odour; acquires a yellowish, or even brown colour; becomes thicker, and specifically heavier; and approaches in its characters to the following variety, *Petroleum.*

In various parts of Persia naphtha is used instead of oil for lamps, &c.

Petroleum.

Bitumen fluidum, crassum; Petroleum; of Wallerius.

Native, and mineral, Tar.

The specific gravity of Petroleum is 0,87.

Its colours vary from a reddish yellow to a reddish black.

Petroleum is so called because it is frequently found exuding in the form of an *oily* liquid from *rocks.* It is very generally considered as an impure form of naphtha; with which its characters closely agree: but it is found in much greater abundance, and in a greater variety of places, than naphtha.

The rock from whence the mineral tar of Coalbrook Dale is obtained is a sandstone.

Petroleum is produced during the spontaneous alteration that takes place in vegetable matter, accumulated in moist heaths and morasses.

Maltha.

Bitumen segne, crassum, nigrum; *Maltha;* of Wallerius.

Cohesive mineral pitch.

This scarcely differs from the foregoing variety; which, by exposure to air and the application of heat, passes into the state of maltha.

Asphaltum.

Bitumen solidum, friabile; Asphaltum; of Wallerius.
Mumia mineralis: said to be frequently employed by the Egyptians in embalming their dead.
Jews' pitch; and *bitumen of Judæa;* from the part of the world where one of its varieties occurs.
It is extremely brittle, and readily reduced to powder.
Specific gravity varies from 1,07 to 1,65.

The term asphaltum is derived from the name of the lake in Judæa, where this substance occurs in great abundance. It first rises in a liquid form to the surface of the water, and there hardens. It differs from the foregoing variety principally in consistence.

Asphaltum is sometimes found in distinct nodules in the substance of a mass of calcareous or of fluor spar.

Klaproth analysed a variety of asphaltum, from Avlona in Albania, the specific gravity of which was 1,20. He says that it burns with a strong and lively flame; and is considered as the principal ingredient in the *Grecian fire* so much employed in former times. One hundred grains of this asphaltum, submitted to the process of destructive distillation, afforded the following results, exclusive of thirty-six cubic inches of carbonated hydrogen gas;

Bituminous Oil	32
Charcoal	30
Water	6
Silex	7,50
Alumine	4,50
Lime	0,75
Oxyd of Iron	1,25
—— of Manganese	0,50
	82,50

Asphaltum may be distinguished from coal by the smell it emits when rubbed. It is, besides, electric; which coal is not. It is distinguished from jet by its brittleness, and by its peculiar odour when rubbed.

Elastic Bitumen of Derbyshire.

This substance is also called mineral caoutchouc; to distinguish it from the vegetable substance of the same name, but more commonly called *Indian rubber*.

Elastic bitumen is met with in a variety of forms in the Odin mine at Castleton, in Derbyshire: in some the bitumen is nearly in a fluid state; in others, in as perfectly an indurated state as asphaltum.

Some of the varieties, which are but slightly elastic, resemble cork.

It is frequently of a brown or reddish brown colour, with a degree of transparency.

One hundred grains of semitransparent elastic bitumen, submitted to the process of destructive distillation, afforded the following results:

Water	1,50
Bituminous Oil . .	73
Mixed Gas, about .	12,50
Charcoal	6,25
Lime	2
Silex	1,50
Alumine	0,25
Oxyd of Iron . . .	0,75
Sulphate of Lime .	0,50
	98,25 *Klapr.*

According to the opinion of Mr. Hatchett, the elasticity of this substance arises from a portion of air, or some other elastic fluid, which is contained between the pores of the bitumen; and during its natural generation accumulates there, and imparts to the whole mass a spongy nature.

RETINASPHAI

This substance is a natur
and asphaltum; and hence
analysed it, was induced to
bituminous substances by th

It is met with in modera
the earthy matter in whic
are situated; but adhering

Its specific gravity is 1,

Its colour is a light oc
the eye be easily mistake
which resemblance, as a
it seems allied to the
logne *; but it posses
inflammability.

When placed on a
with a bright flame; y
which towards the e
slightly tainted with

One hundred grai
the process of destr
lowing results:

*

Water	3
Thick brown oily Bitumen	45
Light spongy Coal . .	23
Mixed Gas	29
	100

The coal yielded about three grains and a half o ashes, which consisted of alumine, silex, iron, and a trace of lime.

By another analysis of the same quantity of this mineral, in which it was submitted to the action of rectified spirit of wine, a quantity of resin was separated: the mass which remained possessed all the properties of asphaltum, and contained about three grains of earthy matter. By this analysis it appeared to consist of the following substances:

Resin	55
Asphaltum	41
Earthy residuum . . .	3
	99

All the substances obtained in the first of these analyses, with the exception of the earthy residuum of the coal, were products: or, according to what has been before advanced, were produced by the decomposition &c. of the component parts of the mineral: in the last they were all educts; that is, they previously existed in their present form.

METALLIC SUBSTANCES.

METALLIC substances occur in a variety of forms; the most remarkable of which are expressed by the following terms:

Native Metals.
Metallic *Oxyds.*
Metallic *Sulphurets.*
Metallic *Salts.*

In what is called their native state they possess those properties on account of which they are principally valuable; as malleability, hardness, and splendour. It frequently happens that two or more are intimately blended in the same mass; and when this is the case, the combination is called a native metallic *alloy.*

Metallic *oxyds* are a combination of the pure metallic substance with oxygen, or that part of atmospherical air which supports the process of combustion and of respiration. A metallic oxyd was formerly called a metallic *calx*. Metallic oxyds are in general of an earthy texture: or, if they possess the splendour and appearance of metals, they are almost always destitute of their tenacity; and are reduced to powder upon the application of a moderate degree of force, as the blow of a hammer for instance. Their specific gravity is greater than that of earthy substances; but less than that of the metals from whence they are derived.

Metallic *sulphurets* are chemical combinations of a metal, but more commonly a metallic oxyd, with sulphur: they frequently have a remarkable degree of splendour and many of the external characters of a metal; but they are readily reduced to powder. In many instances arsenic is contained as well as sulphur; and the presence of either substance is easily ascertained by means of the blowpipe: the sulphur manifesting itself by its pungent odour and the well known colour of its flame: the arsenic by a white smoke, and a smell resembling garlick.

A metallic *salt* is a chemical combination of a metallic oxyd with an acid. Some of the metallic salts, those for instance which are most remarkable for their taste and solubility, have been already described in the beginning of this volume.

The term metallic *ore* is by some applied to those natural forms only which require some chemical process in order to bring them back to their supposed original state; and by this process they are consequently said to be *reduced:* by others it is indiscriminately applied to all the natural forms; and includes therefore native metallic substances. In early publications the word is spelt "ewer."

Metallic substances principally occur in veins, and in all varieties of rocks; but more abundantly in primitive schistus than any other. And, upon the whole, primitive rocks are the most metalliferous.

Derbyshire,* which is a secondary country, affords a very remarkable exception to this rule.

◆

The history of mining in this island has been traced back to a very early period: and it appears that lead was the metal most abundantly worked in Britian, at the time of its conquest by the Romans. They of course improved the art; and the miners, left by them, continued for many ages to work in the peak of Derbyshire; in the Mendip hills; in the tin mines of Cornwall; and in the iron mines of the forest of Dean. In the last mentioned place, traces of their works and furnaces are even now occasionally met with; and it has happened within a few years, that the dross or slag of the iron found in these old works has been again submitted to the furnace, for the purpose of extracting the metal contained in it; the quantity left in it, from the imperfect state of the art at that time, being very considerable.

The Roman miners for some centuries governed themselves by their own laws, partly Roman and partly Belgic. Edward I. erected the court parliament of Stannaries. Other kings, especially Henry VII. appointed commissioners to superintend the mines.

Queen Elizabeth formed a corporation having the direction of mines and mineral works, to which she granted exclusive privileges: she also invited many foreigners into England, giving them permission to dig for metallic ores. Among these foreigners was Christopher Schutz, a native of Annaberg in Saxony, who was particularly skilled in finding calamine; and in making brass. He introduced the method of drawing iron wire by means of engines; which before the seventh year of Queen Elizabeth's reign had been drawn by man's strength in the forest of Dean. This wire was principally used in making bird cages and cards for combing wool.

The foregoing anecdotes of the history of mining have been principally collected from Stringer's Mineral Kingdom.

PLATINA.

Aurum album; from its great specific gravity, and white colour.

Specific gravity before it is purified 15,60; after it has been purified 20,98.

The name of this metal is derived from its resemblance, in its native state, to small grains of silver; the word *platina* being a diminutive of *plata*, which in Spanish signifies silver.

The existence of platina was scarcely known in Europe before the year 1740. In its native state it occurs in small apparently flattened grains of a dull silvery lustre, and in general about the size of a small pin's head; mixed with minute particles of magnetic iron, gold, and quartz. It is, besides, alloyed with several metallic substances; some of which possess characters that distinguish them from all other metallic substances hitherto known.

Quicksilver is sometimes made use of for the purpose of separating the gold that accompanies native platina: and this accounts for the occasional presence of particles of quicksilver in the platina of commerce.

M. Vauquelin has lately discovered the existence of platina in a silver ore from Spain; into the composition of which it enters in the proportion of one tenth. With the exception of this single instance, platina has only yet been found in the gold mines of America; near Choco in Peru, and at Santa-Fe near Carthagena. From the flattened appearance of its particles Wallerius supposes that it has been separated from gold ores by means of stamping mills. According to Brogniart it is found in alluvial tracts containing fossile wood, and covered over with fragments of basalt.

Platina is less expanded by heat than any of the metals; and hence it is employed with advantage in the construction of geometrical instruments. It is also very useful for the purpose of making telescopic mirrors; partly in consequence of its resisting the action of the air without tarnishing; and partly because from its great density it possesses in a higher degree than other metals the power of reflecting light.

Platina in its native state is distinguished easily from all other minerals by its peculiar appearance. When purified it is distinguished by its colour and weight.

GOLD.

NATIVE GOLD.

The specific gravity of native gold exceeds 12, more or less in proportion to the quantity of copper or silver with which it is alloyed: the specific gravity of pure gold is 19,25.

Its crystallized forms are

The regular octohedron.

The garnet shaped crystal having 24 trapezoidal faces.

The cube?

A four-sided prism terminated at eàch extremity by a four sided pyramid?

A dodecahedron?

M. Haüy observes that the second variety is the most rare: of the existence of the three last varieties he seems to speak with some degree of doubt. The form of crystallized gold is not often accurately defined.

Gold also occurs of a dendritical form; the ramifications in some instances appearing to be made up of small octohedral crystals, accumulated one above the other.

Sometimes it is met with in delicate capillary fila-

ments ; or contained in a st
scales or plates, which have
In the foregoing instances it
in the substances still conta

In mountain streams an
regular nodular masses un
as in the *stream works*, a
wall ; and in ferruginous
tains, in Ireland. Mr.
found there, the largest
weighed twenty-two oun
the form of minute gr
many rivers; but particu

The sand of any rive
it contains, provided it
a hundred weight : bu
often yields sixty thre
pounds weight ; which
than fifty times as mu

The author of Lor
was first discovered i
the mountains whic
Janeiro : the most
is, that the Indians
settlements were ob
tioned, to make us
and by inquiry it w
sand and gravel d
from the neighbou

voyage saw a large fragment of one of these rocks, in which a considerable lump of gold was entangled. He says that the slaves, who were employed to collect the gold, were bound to supply their masters with fifty grains a day, the value of which was equal to about nine shillings. What they collected above fifty grains they had the right of retaining for themselves.

Gold is commonly recovered from the sand containing it by the process of washing: by which, in consequence of the difference in the specific gravity of the two substances, a separation is easily effected: the gold almost immediately subsiding; while the sand is poured off together with the water, that for a time is capable of holding it in suspension.

In some instances the gold contained in the sand of rivers has been brought down from the mountains where thore rivers originate; but this is not always the case: so that those who have traced the current of a river towards its source, with the hope of finding a more abundant supply of gold in that quarter, have often been deceived. In some rivers, indeed, the sand of those parts, which are farther removed from the source, is richer in gold than the sand of those parts which are nearer; which of itself is almost sufficient to prove that the gold has not in these instances been brought from the mountains. In the case of the Tesino, which flows through one of the lakes in the north of Italy, the quantity of gold in that part of the river, which is below the lake, is in much greater abundance than in that part of the river which is above the lake; where indeed a very small quantity, if any, is found: but, supposing the gold to have been detached from the mountains near the source, it would hardly have been conveyed through the lake, where the current of the river must necessarily have been much slackened, to be deposited in a more distant part where the current was much stronger.

But there are strong positive grounds for supposing that the gold found in the sand of many rivers has been derived from the soil surrounding that part of their course where it is met with: for it is found in very circumscribed situations; and the quantity is always greater after violent showers have fallen upon the open country immediately adjoining; and the soil of this adjoining country, if washed, itself affords gold.

Most of the gold of commerce comes from Africa and America: and, from various accounts, it appears that alluvial districts afford by far the greatest proportion of this; and that the alluvion in which it is contained is principally a ferruginous sand. The only considerable gold mines in Europe are those of Hungary.

Gold is never found in any other than a native state; and is usually alloyed with copper, or silver, or iron: sometimes, with all of these.

A variety of native gold analysed by Lampadius consisted of

Gold	96,9
Silver	2
Iron	1,1
	100,0

On the separation and refinement of NATIVE GOLD.

Native gold is separated from the substances accompanying it by means simply mechanical, as pounding and washing; or by fusion with lead; or by the process called amalgamation. These processes are employed previously to the operation of refinement.

The process of *washing*, the principle of which has been already explained, is commonly employed in separating gold from the sand of rivers &c.

The process by *fusion* with lead is applied principally to the ores of other metals, which contain a sufficient proportion of gold to repay the cost of extraction: these ores are for the most part sulphurets of copper &c., but particularly sulphuret of iron, or iron pyrites: and are consequently called *auriferous.* These sulphurets are roasted, or exposed to a sufficient degree of heat to expel most of their sulphur; which operation in a great measure disengages the particles of gold before enveloped in the mass; and then they are melted with lead. The lead combines with the gold, which is recovered by the process of refinement.

The process by amalgamation depends on the property which quicksilver possesses of attracting and combining with gold; and is applied either to auriferous metallic sulphurets, or to native gold contained in indurated rocks. In either instance the substances containing the gold are stamped and triturated with quicksilver, the sulphurets however being previously roasted; and during the process the quicksilver absorbs every particle of the gold, loses proportionally its fluidity, and forms that kind of alloy which is called an *amalgam:* the term amalgam being applied instead of alloy to a combination of any metal with quicksilver. This amalgam is afterwards washed by a current of water, in order to separate the particles of earthy matter; and a great portion of the quicksilver is separated from the gold by straining it forcibly through linen bags: the gold which remains on the linen is then exposed to a degree of heat sufficient to volatilize every particle of the quicksilver; and the gold itself remains behind, alloyed however in general with silver, and sometimes other metals.

The gold separated by any of the three foregoing processes is afterwards melted with the quantity of lead that has by experience been found necessary, and is submitted to the process of cuppellation. This process is so named from the vessel employed to hold the mixture of the lead and gold, called a coppel or cuppel: it is made of calcined bones; which are powdered, and with the smallest quantity of water possible formed into the appropriate shape: the substance of this is very porous, and on that circumstance in a great measure depends its use.

The use of the lead in the process of cuppellation depends partly on the property which it possesses of being vitrified by the joint action of air and a high degree of heat; and partly on its power of promoting the vitrifaction of almost all the other metals, except gold or silver. The gold then, together with the lead, being placed on the cuppel; and a strong heat being applied, together with a constant current of atmospherical air; the mass is soon melted: and the lead being vitrified by the joint action of the heat and air, and vitrifying the base metals with which the native gold was alloyed, sinks in the form of a viscid glass into the substance of the cuppel. For the effectual separation of tin or iron, sulphuret of antimony is used after the lead. By a careful management of this process the lead and all the other metals are separated, and the mass which remains behind consists entirely of the gold, mixed with whatever proportion of silver was originally contained in it.

If the separation of the silver is required, the gold, after the completion of the foregoing process, is melted with three times its weight of silver: the mixed mass when consolidated is flattened into laminæ, and boiled in nitric acid; which dissolves the silver, and leaves the gold in a state of purity.

SILVER.

Native Silver.

Virgin silver.

Specific gravity about 10; but this varies according to the degree of purity of the silver.

The crystallized forms of native silver are

The regular octohedron.

The cube.

The cubo-octohedron; which is obtained artificially by cutting off each solid angle of the cube, so as to produce eight new equilateral triangular surfaces: the crystal then consists of fourteen sides; the remaining six of which are squares.

Native silver also occurs in a dendritical form; originating, as in the instance of gold, from the accumulation of numerous octohedral or cubic crystals one above the other. Sometimes these ramifications diverge and radiate: sometimes they are compressed between two laminæ of the stony matrix in which they occur; and then, being situated all in the same plane, they resemble in some measure the leaves of fern: at other times the ramifications cross each other at right angles, and produce a reticulated or pectinated appearance.

Native silver also occurs in a capillary form ; the filaments differing in size in different instances, and curved in various directions : and in thin plates, in the fissures of the matrix in which it is found. Sometimes it is met with in amorphous masses, and in grains ; the latter however is a very rare form of native silver.

Native silver is rarely absolutely pure ; being commonly alloyed with copper or gold, or both : sometimes with iron or arsenic.

The same parts of America that are rich in gold are equally or even more productive of silver : Mr. Jameson says, that in the cabinet of Vienna there is a rolled piece of native silver from Spanish America, the weight of which is thirty-six pounds.

Native silver is met with in many parts of Europe : but the mines of Saxony, Bohemia, and Suabia afford the greatest quantity.

The matrix, in which it is found, and the substances which accompany it are various.

Specimens of native silver have often a superficial tarnish, owing to the union of sulphur with the metal : this differs therefore from the tarnish of metals in general, which is occasioned by a superficial union of the metal with the oxygen of the atmosphere.

Native silver is distinguished from native antimony, and antimonial silver, by its tenacity and compact texture; antimony and antimonial silver being brittle, and of a laminated structure. It is distinguished from arsenical cobalt by the garlick smell, which the latter emits upon the application of the blowpipe.

SILVER *alloyed with* ANTIMONY.

White Antimonial Silver ore.
Antimoniated Native Silver; of Kirwan.
Slightly malleable when struck cautiously.
Of a silvery white colour.
Easily reduced by the blowpipe; the antimony flying off in the form of a white vapour.
Structure irregularly laminated; occasionally granular.
Specific gravity varies from 9,44 to 10,00.
Primitive form not ascertained; apparently the regular hexhedral prism.

	Fine grained *Antimoniated Silver of Furstemberg.*	Coarse grained *Antimoniated Silver of Furstemberg.*
Silver	84	76
Antimony	16	24
	100 *Klapr.*	100 *Klapr.*

Antimoniated Silver of St. Andreasberg.

Silver	77	78	75,25
Antimony	23	22	24,75
	100 *Klapr.*	100 *Vauq.*	100,00 *Abich.*

Antimoniated silver does not often occur. It has been met with near Guadalcanal, in Spain; in the territory of Furstemberg, in Suabia; and near St. Andreasberg, in the Hartz: it is usually accompanied with calcareous spar, and sulphate of baryt; rarely with fluor spar. It has often been mistaken for a variety of silver ore called arsenical silver; but the latter emits a very strong smell of garlick upon the application of the blowpipe, which antimoniated silver does not. It is distinguished from native silver by its brittleness.

Arsenical iron pyrites and arsenical cobalt resemble it: but the former strikes fire with steel; and both emit a strong smell of garlick when triturated.

SILVER *alloyed with* ARSENIC *and* IRON.

Arsenico-martial Silver ore; of Kirwan.

Iron	44,25
Arsenic	35
Silver	12,75
Antimony	4
	96,00 *Klapr.*

This ore is of very rare occurrence: it is usually found with native arsenic, red silver ore, granular galena, and blende, in close laminated calcareous spar. The foregoing analysis is of a specimen from St. Andreasberg in the Hartz. M. Haüy thinks that notwithstanding their great proportion the iron and arsenic are to be considered as accidental; and that the ore is a variety of antimoniated silver. The mutual proportion of the silver and the antimony is very nearly the same in arsenical, as in antimoniated silver; for 12,75 : 4 nearly as 76 : 24 *.

SULPHURET OF SILVER.

Sulphurated silver ore; of Kirwan.

Glaserz, or *glassy* ore; of the Germans. The term *glaserz* is supposed to be a corruption of *glanzerz,* or *shining* ore: for the ore in question has not the least resemblance to any thing like glass, but has frequently a considerable degree of metallic splendour.

Vitreous silver ore. The term vitreous ore is merely a translation of the German word *glaserz*; the probable origin of which has been just explained.

It is of a leaden grey colour: the fresh surface is of considerable lustre; but soon tarnishes upon exposure.

Easily reducible by the blowpipe.

It is malleable, and may readily be cut by the knife.

---

* Vid. the second Analysis, p. 85.

Specific gravity varies from 6,90 to 7,21.

Its crystalline forms are

The cube.

The cubo-octohedron.

The octohedron.

The garnet-shaped dodecahedron.

The crystals are often aggregated in rows.

It occurs also in dendritic, and other forms; and completely amorphous.

Silver	85	84
Sulphur	15	16
	100 *Klapr.*	100 *Sage.*

This is the richest of all the ores of silver; not only on account of the proportion of silver contained, but the ease with which it is reduced. By a well regulated heat the metallic silver may be made to exude in a curled capillary form: and the sulphuret of silver thus altered is occasionally sold as native silver; some of the most beautiful forms of which it closely resembles. Perhaps in some instances native silver may have been occasionally derived from a similar source.

The malleability of this substance, as being a metallic sulphuret, is very remarkable. It receives any impression so accurately that it has been used for stamping medals.

Sulphuret of silver is met with commonly in Hungary, Bohemia, Saxony, and Norway.

ANTIMONIATED SULPHURET OF SILVER.

Red silver ore.

When pure it is of a clear red colour, and slightly transparent; but by exposure it acquires a metallic steel grey brilliancy, and becomes opaque.

It is a conductor of electricity.

It is brittle and easily scratched by the knife.

Reducible by the blowpipe.

Specific gravity varies from 5,56 to 5,68.

Primitive form, an obtuse rhomboid; the plane angles of which are 104ᵈ 28′ and 75ᵈ 32′. It occurs under a great variety of secondary forms; but is not often very distinctly crystallized.

Silver . .	62	Silver . .	56,67
Antimony .	18,5	Antimony .	16,13
Sulphur .	11	Sulphur . .	15,07
Sulphuric Acid	8,5	Oxygen . .	12,13
	100,0 *Klapr.*		100,00 *Vauq.*

The superficial alteration of colour that takes place in red silver, by exposure to air, is supposed to dedend upon the partial loss of the oxygen contained in it. The red colour is always perceptible upon triturating it; and may often be rendered visible by the scratch of a knife.

The silver contained in this ore may be made to assume a capillary form by the method described in the history of the sulphuret of silver.

Red silver ore occurs in considerable abundance in the mines of Saxony and the Hartz, and in Bohemia.

This variety of silver is distinguished from realgar, or sulphuret of arsenic, by its greater specific gravity; and by the red colour of its powder: realgar, besides, acquires the negative or resinous electricity by friction; but red silver ore is a conductor of the electric fluid. It is distinguished from cinnabar or sulphuret of quicksilver by its inferior specific gravity; and in being only partially volatilized by heat.

Those varieties which have lost their colour may be distinguished from sulphuret of silver, by their brittleness: from specular iron ore, by their higher degree of colour when triturated, and by their not affecting the magnetic needle: from grey copper ore, by their red colour when pulverized; and by their being more easily scratched.

Black Silver Ore.

Sooty ore of silver; of Kirwan.
Silver mulm.

It often occurs in a black pulverulent form; sometimes in distinct crystals which have a corroded appearance. Internally it has a metallic lustre, and resembles the sulphuret of silver or vitreous silver ore; but it has not the malleability of the latter substance:

hence it has been called "*brittle vitreous silver* "ore."

By many it is considered as an altered form of red silver ore.

Silver	66,50
Antimony . .	10
Iron	5
Sulphur . . .	12
	93,50 *Klapr.*

Muriate of Silver.

Horn Silver; from its occasional resemblance to horn in transparency, toughness, and the manner in which it yields to the knife.

When pure it is nearly colourless; and has a considerable degree of transparency: hence it was formerly called *glassy* ore of silver.

Fusible by the blowpipe; melting much in the same manner as wax: it is afterwards reduced.

Specific gravity 4,74.

It occurs crystallized in a cubic form.

Silver of Saxony or Bohemia.	
Silver	67,75
Muriatic Acid . .	21
Oxyd of Iron . .	6
Alumine	1,75
Sulphuric Acid . .	0,25
	96,75 *Klapr.*

This is now a very rare ore of silver: and its external characters are not sufficiently distinct to admit of a general description.

The mines of Saxony and Bohemia were rich in this ore in the sixteenth century: and in the electoral cabinet at Dresden is a mass weighing several pounds, which probably came from thence.

QUICKSILVER.

NATIVE QUICKSILVER.

Native Mercury; of Kirwan.
Specific gravity 13,58.

It is unnecessary to dwell on the characters of a substance so remarkable, and which occurs so commonly, as this.

The matrix in which it most frequently occurs is an argillaceous schist, or marl: and upon breaking a specimen of this kind numerous brilliant metallic globules appear, disseminated through the earthy substance, or accumulated in the crevices and cavities in its interior.

The quicksilver may be collected in these instances by mechanical means; or, still more completely, by distillation.

Native quicksilver is found abundantly in the mines of Idria; and of the Duchy of Deux-Ponts; and of Almaden, in Spain. There is a very rich mine of it also near Guanca Velica, in Peru.

QUICKSILVER *alloyed with* SILVER.

Natural amalgam; of Kirwan.

This is found sometimes in a soft, and almost fluid state; sometimes solid and crystallized.

Quicksilver	64	75
Silver	36	25
	100 *Klapr.*	100 *Heyer.*

This variety occurs principally in the mines of the Duchy of Deux-Ponts; and accompanies native quicksilver, and sulphuret of quicksilver. The greater the proportion of quicksilver contained, the more fluid of course is the amalgam.

SULPHURET OF QUICKSILVER.

Cinnabar.

Native cinnabar, of Kirwan; to distinguish it from the artificially prepared cinnabar, or vermilion.

Minium; of Pliny.

Easily scratched by the knife.

Volatilized entirely by the action of the blowpipe.

Specific gravity varies from 6,90 to 10,21.

Primitive form, the regular hexhedral prism.

Quicksilver	80
Sulphur	20
	100 *Sage.*

Cinnabar is frequently the matrix of native quicksilver: it is principally found in the mines of Idria, Deux-Ponts, and Almaden in Spain. The mines of Spain are the most ancient, and were worked in the time of the Romans.

It appears from Vitruvius that the term *minium* was derived from the name of a river in Spain; and there are several passages in Pliny which shew that the term minium was applied to a substance corresponding with our cinnabar. He says that almost all the minium in use at Rome came from Spain; and that the ore was sent over from Spain sealed. The first circumstance shews the abundance in which minium was met with in Spain; the last, its value: both are characteristic marks of the cinnabar of the present day. He also says that those who were employed in reducing the minium to powder wore loose bladders over their face, lest they should inhale the dust; the effects of which were very pernicious: this custom is also observed at the present day by those who are employed for a length of time together in triturating preparations of quicksilver.

The term cinnabar was originally applied to the drug commonly called "dragon's blood," which is of a dull red colour: it was afterwards transferred to the ore of quicksilver now under consideration.

Sulphuret of quicksilver may easily be reduced by mixing it with quick-lime or iron filings, and submitting the mass to the process of distillation: the lime or the iron attracts the sulphur, and the quicksilver passes over in a disengaged state.

This variety of quicksilver is commonly met with in clay, or in ochry earths; when in a fine pulverulent state its colour is often very bright; and it is then called native vermilion. It is occasionally of a compact texture and brown liver colour; whence the term hepatic cinnabar: cinnabar of this kind emits a bituminous smell when exposed to the action of the blowpipe: it derives this smell from bituminous schistus with which it is mixed. Much of the cinnabar of Idria is of this kind.

Cinnabar is distinguished from red silver by the red streak it gives when rubbed on paper; and in being entirely volatilized by heat: from realgar, by the bright red colour of its powder; the colour of realgar, when pulverized, being yellow: the same mark will distinguish it from chromate of lead: from red cobalt ore, by its more lively red colour; and in not emitting a smell of garlick, when exposed to the blowpipe.

MURIATE OF QUICKSILVER.

Horn quicksilver; from its analogy in composition to muriate of silver, called *hornsilver.*

It is brittle.

Volatilized by the blowpipe.

It has not the softness of hornsilver, and may thus be distinguished from it. It has only occurred in the mines of Deux-Ponts.

Oxyd of Quicksilver . .	70
Muriatic Acid	29
	99

COPPER.

NATIVE COPPER.

Specific gravity 8,58.
The principal crystalline forms are
The cube.
The octohedron.
The cubo-octohedron.
It also occurs in dendritical and other forms, much in the same manner as gold and silver; but in larger masses.

The word copper, *cuprum*, appears to be derived from the name of an artificial alloy of this metal, called *æs cyprium;* which was a compound of copper and tin. In the early natural historians *æs*, when used simply, very often signifies copper.

Native copper, which is as easily recognized as most substances by its external characters, is met with in many parts of the world: sometimes distinctly crystallized; more frequently ramifying in various forms through the substance containing it.

Some of the most beautiful specimens of native copper are met with in Siberia, in the eastern extremity of the Oural mountains, in about the sixtieth degree of latitude: the matrix of this copper is a granular white carbonate of lime.

Native copper is also met with in quartz, through which it often penetrates in the form of irregularly prismatic bars; in serpentine; in varieties of basalt and porphyry; and in granite.

According to Mr. Jameson it is frequently found in great masses dispersed over the surface of the earth, in uncultivated countries; whence Werner conjectures that it was the first metal worked by man. From its obvious metallic characters this opinion may be considered as very probable, especially when supported by the account which is given* of some of the savage tribes in the north western parts of America; who, though little civilized in most respects, have applied to domestic purposes the native copper with which their country abounds; and, from one of the uses to which they have applied it, are commonly denominated copper-knived Indians.

Lucretius alludes to the early use of copper in these words:

> —— Prior *æris* erat, quam ferri cognitus usus *.

When native copper is met with in the body of primitive limestone, and other rocks which appear to have undergone a state of fusion, it is presumed that it originally crystallized in the situation where it is now found. In particular situations it appears to be the result of a secondary formation; and is conjectured by some to have been derived from the saline form of this metal, called blue vitriol; which is a combination of copper and sulphuric acid. In these instances it is supposed that some substance, having a stronger attraction for sulphuric acid than copper, has decomposed the salt; and that the copper has been precipitated in consequence. Thus into the water of some mines, holding blue vitriol in solution, it is customary to throw pieces of iron in order to decompose that metallic salt; and the copper is precipitated on the iron in proportion as the decomposition proceeds. This method of separating copper was first practised at Herengrund, near Neusol, in Hungary. The copper so obtained is called copper of *cementation*, or *cement* copper: but Mr. Price, in his " Mineralogia Cornubiensis," says, that the word cement is a corruption of " Ziment," which is the name of a place near Herengrund. From observing what happens in this artificial process, and comparing the effect with the occasional stalagmitic appearance of native copper, some mineralogists are inclined to attribute this appearance to a similar origin.

---

* Lib. v.

Mr. Jameson mentions a mass of native copper, on the authority of Professor Vandilli, weighing 2600 Portuguese pounds. It is said to have been found in a valley near Cachoeira, in Brasil.

RED OXYD OF COPPER.

Calciform red Copper ore; of Kirwan.
Ruby Copper ore.
It is reducible by the blowpipe.
Easily scratched and pulverized.
Specific gravity 3,95.
Primitive form, the regular octohedron. It occurs also in cubes; and in mixed forms of the octohedron and cube. It is sometimes found in delicate capillary filaments of a bright red colour: sometimes of a laminated structure; and, occasionally, amorphous.

Copper	85
Oxygen	15
	100

This variety of copper occurs in several mines in Cornwall. It is sometimes intimately mixed with the native metal. Many of the Cornish specimens consist of a spongy or carious mass of amorphous red copper ore, the cavities of which are richly set with octohedral crystals of the same substance. The size of these crystals rarely exceeds that of a pea, supposing it cut into an octohedral form; but they are remarkably distinct, and are occasionally transparent, and of a fire red ruby colour. By exposure they seem to lose their transparency, and even their colour; acquiring by degrees a steel grey colour, and completely metallic lustre. In their passage from the one to the other state, they have occasionally a very beautiful superficial iridescence. But to whatever extent the red colour of this ore be altered, it may always be rendered visible by triturating a small portion of its substance.

If red copper ore be pulverized and thrown into nitric acid, a violent effervescence ensues, and the copper is dissolved; the liquor at the same time acquiring a green colour: from the effervescence which it here occasions, red copper was at first supposed to be an ore containing carbonic acid or fixed air; but the cause of the effervescence depends on the decomposition of the nitric acid, by which a quantity of nitrous gas, or perhaps nitrous acid gas, is set at liberty. Were any carbonic acid present in the ore, an effervescence ought equally to take place during its solution in muriatic acid; but this is not the case.

It may perhaps be worth while to explain in a more particular manner the nature and occasion of the effervescence above described: as it will serve to elucidate the manner in which metals in general combine with acids.

The gas, which is separated in the instance above mentioned, when combined with the necessary proportion of oxygen, forms nitric acid: on the other hand, if the necessary proportion of oxygen be separated from nitric acid, it assumes the form of this gas:

and as metals in general are strongly disposed to combine with oxygen to a certain extent, they often readily decompose substances containing oxygen, in order to saturate themselves: nor will they indeed, unless previously oxydated, unite with acids. And though red copper is a natural combination of the metal with oxygen, yet it is not combined with as much oxygen as it is capable of combining with: it therefore decomposes the nitric acid; and consequently disengages, according to the explanation above given, a quantity of nitrous or nitrous acid gas; which by its escape occasions the effervescence observable during the solution of red copper in nitric acid.

As muriatic acid is not liable to a similar decomposition, and as the ore contains a sufficient proportion of oxygen to render it soluble in that acid, red copper is gradually dissolved in it without any effervescence.

If red copper be simply heated, it melts with comparative difficulty: if heated to even a less degree, in contact with charcoal, its oxygen unites with the charcoal, and forms carbonic acid; which flies off in an aëriform state: the metal is at the same time reduced, and, where the experiment is conducted by means of the blowpipe, appears in the form of a brilliant globule. The reduction in the large way will easily be understood from what has just been said; for the ore being mixed with charcoal, or any tolerably pure form of coal, its oxygen is separated, and the reduced metallic particles sink, and unite together in one mass at the bottom of the crucible or furnace, in which the operation has been carried on.

From the analysis already given it appears, that this is an exceedingly rich copper ore: and its value is enhanced by the ease with which it is reduced.

Red copper is found in various parts of Europe, usually accompanied with native copper, and malachite or green copper ore.

Wallerius in speaking of this ore, which he denominates "ochra cupri rubra," says that there is a very productive mine of it in Dalecarlia, called "magnum cuprimontium;" which is said to have been discovered by the observation that a goat, fed in that neighbourhood, used to return home every evening with its hide reddened. There is a similar account in Theophrastus, or Pliny, of the discovery of a mine of cinnabar, in Asia Minor.

Red copper is distinguished from red silver by the effervescence it occasions, when thrown into nitric acid; and by its disposition to a cubic or an octohedral crystallization: from cinnabar, by its solubility in nitric acid; and by its reduction to a metallic globule under the action of the blowpipe, whereas cinnabar is immediately volatilized: from red plumose antimony, by the same circumstance; and also by its brighter red colour.

Earthy red Oxyd of Copper, mixed with *brown* Oxyd of Iron.

Tile-ore.
Brick-red copper ore; of Kirwan.

This ore, which is called tile-ore from its colour, consists of an earthy form of red copper ore intimately mixed with brown oxyd of iron. It contains from one fifth to one half of copper; those varieties which approach nearest to a red colour containing the greatest proportion of copper. The varieties that are of a brown colour contain the greatest proportion of iron.

It is almost always found in the neighbourhood of red copper ore.

When very highly indurated its fracture resembles that of *pitch*, and it has from that circumstance been called pitch-ore of copper.

SULPHURET OF COPPER.

The colour of sulphuret of copper is very different in different instances: it will be convenient therefore to arrange the varieties of this ore under different heads, according to the predominant colour; beginning with that which contains the greatest proportion of copper.

Grey Sulphuret of Copper.

Cuprum *sulphure* mineralisatum, minera obscure nitente, *grisea*, molli; of Wallerius.

Cuprum *vitreum;* of the same author.

Vitreous Copper ore; of Kirwan: the origin of the term *vitreous* seems to have arisen in this instance from a similar mistake with that described under the head of sulphuret of silver, or vitreous silver ore *.

It is very brittle in general: the purer varieties are slightly malleable.

Its colour is a dull iron grey; which by exposure becomes black.

Reducible by the blowpipe: leaving a metallic button; which is of a grey colour, in consequence of the iron contained in it.

Specific gravity varies from 4,81 to 5,33.

It is sometimes crystallized in regular hexhedral prisms: but it commonly occurs in amorphous masses.

Copper	78,50
Sulphur	18,50
Iron	2,25
Silex	0,75
	100,00 *Klapr.*

---

* Vid. p. 87.

The variety of which the analysis has just been given was moderately soft; and came from the district of Catharinaburg, in Siberia.

This is a very rich ore of copper; but not so easily reduced as the preceding, on account of the sulphur contained in it. It is met with principally in Siberia, Sweden, Saxony, and in Cornwall: the last mentioned place affords the most distinctly crystallized specimens of the grey sulphuret of copper.

A considerable quantity of this ore has lately been recovered from the refuse of several old mines in Cornwall, which were worked seventy or eighty years since; the valuable nature of this ore not being known there, at that time.

It is commonly accompanied by yellow sulphuret of copper.

Grey sulphuret of copper may be distinguished from the discoloured varieties of red copper ore, in not effervescing with nitric acid: from sulphuret o silver, by its brittleness; and by the grey colour of the metallic button which it leaves after the action of the blowpipe.

Variegated or *iridescent* Sulphuret of Copper.

Cuprum *sulphure* et ferro mineralisatum, minera solida nitente, *violacea* vel *cærulescente;* of Wallerius.

Minera cupri *hepatica, fusca;* of the same author.

Purple copper ore; of Kirwan.

The colours of this variety upon the whole resemble those of tarnished steel; and often gradually fade into a uniform bluish bronze colour: this change takes place in consequence of exposure to atmospherical air.

Reducible by the blowpipe much in the same manner as the preceding variety.

Specific gravity varies from 4,30 to 4,95.

	Variegated Sulphuret from Norway.	*Variegated Sulphuret from Silesia.*
Copper	69,50	58
Sulphur	19	19
Iron	7,50	18
Oxygen	4	5
	100,00 *Klapr.*	100 *Klapr.*

This variety differs from the preceding, with respect to its component parts, in containing a smaller proportion of copper, and a greater proportion of iron. The copper is, besides, in a slightly oxydated state in this instance; whereas in the preceding it is completely in a metallic state. The variegated colour is supposed by M. Klaproth to be owing to the slightly oxydated state of the metal: so, in steel and other metallic substances, the beginning of their oxydation is indicated by a similar diversity of colours. In the last mentioned substances indeed the change of colour is only superficial, for the oxygen of the atmosphere can only act upon the surface of the metal: in the variegated copper ore the diversity of colour penetrates the whole mass, in consequence of the universal presence of the oxydating principle throughout the substance of the ore. As however the oxydation is slight, the metal is disposed to absorb a further portion of oxygen; and the uniform brown colour is gradually produced in consequence, as often as a fresh surface is exposed to the action of the air.

Yellow Sulphuret of Copper.

Cuprum *sulphure* et ferro mineralisatum, minera colore *aureo* vel *variegato* nitente; of Wallerius.

Minera cupri *flava*; and, minera cupri *viridescens*; of the same author.

Copper *pyrites*; from its resemblance to the natural form of iron called *iron* pyrites.

Yellow copper ore; of Kirwan.

Pigeons' neck, and *Peacock* copper pyrites: these terms are applied to the iridescent varieties.

It is not in the slightest degree malleable.

Yields easily to the file; and rarely strikes fire with steel.

Its colour is for the most part a greenish yellow; with occasionally a superficial iridescence.

Fusible into a black globule by the blowpipe.

Specific gravity varies from 4,08 to 4,34.

Primitive form, the regular tetrahedron. On account of the peculiarity of the primitive form, M. Haüy makes the yellow sulphuret a distinct species from the two preceding.

Copper . . .	40 . . .	41
Iron	40 . . .	17,1
Sulphur . . .	20 . . .	45,1
	100 *Sage*	103,2 *Lampadius*

The increased weight of the substance in the analysis of Lampadius depended perhaps on the oxydation of the metallic part during the process of the analysis.

It appears by the foregoing analyses, that in some instances the proportion of iron contained in yellow sulphuret of copper is equal to the copper itself: so that with respect to the natural classification, it would be difficult to determine under the head of which metal such an ore should be arranged: in an artificial classification there is not the same difficulty, because if the substance is employed for the purpose of extracting the copper, this will be sufficient to justify its being classed among the ores of that metal.

On the other hand all the natural forms of sulphuret of iron, or iron pyrites, contain some proportion of copper; and this proportion is so variable that no fixed limit can be agreed on to afford grounds for an accurate definition of either substance. Romé de Lisle attempted to establish a difference by means of the crystalline form, asserting that in the yellow sulphuret of copper this was always a complete or modified tetrahedron: but copper pyrites sometimes occurs in the form of the regular octohedron; a form which equally belongs to the sulphuret of iron, or iron pyrites.

From the difficulty attending a strict classification of the varieties of the substance under consideration, M. Haüy has simply called them by the name of copper pyrites: under which may properly be classed all those crystals of a brass yellow, or greenish yellow colour, the form of which is a tetrahedron, or a modification of the tetrahedron. In the amorphous varieties copper pyrites may upon the whole be distinguished from iron pyrites by its deeper yellow colour, which is also tinged with a shade of green; and by its inferior degree of hardness.

Copper pyrites often undergoes a superficial alteration of colour, in consequence of exposure to air; passing through numerous iridescent shades, principally of purple, blue, and red: these afterwards tarnish and become fainter; and at last are blended together into a uniform dull brown or greenish brown colour. It has already been mentioned that the calcareous spar of the Ecton copper mine frequently contains very beautifully iridescent crystals of copper pyrites: the form of these crystals is for the most part tetrahedral; they are often grouped together with great regularity, so as to form larger tetrahedrons, and pyramids *.

Copper pyrites sometimes occurs in a mamillated form: the surface of the tubercles is either very obscurely iridescent, or of a light greenish bronze colour; and here and there incrusted with small irregular crystals of the same nature, but of a bluish black colour, disposed in the manner of filigree work. The dark colour both of the mamillated masses and of the crystals is only superficial: the interior substance is of a uniform yellow.

Copper pyrites is the ore from which a great proportion of the copper of commerce is obtained. The first part of the process consists in the separation of the sulphur by means of fire, and is technically called *roasting* the ore.

This is conducted either in the open air, or in large chambers: combustible materials are mixed with the ore that has been broken down into fragments of a convenient size; and the whole is then piled in heaps, and set on fire.

---

* Vid. vol. i. p. 53.

In all instances it is necessary that this process should be repeated three or four times, in consequence of the strong degree of attraction that exists between the sulphur and the metal: in some, ten or twelve times; or even more. The roasted ore is afterwards melted in a furnace; from which it passes into basons placed beneath: in this state it is of a blackish brown colour, and very brittle; containing a less proportion of sulphur than the native ore, but in other respects equally unfit for economical purposes. It is therefore broken up, and again and again fused; the process being frequently repeated as many as six, or eight, or even ten times. When by these repeated fusions the sulphur has been nearly separated, the copper shews itself in distinct patches diffused through the substance of the imperfectly reduced mass; sometimes accumulated in very delicate capillary filaments.

But, after all the sulphur has been separated, the copper generally contains some portion of iron, or zinc, or other metals; and these are separated by a process somewhat analogous to the cuppeliation of gold; for the copper is exposed while in fusion to a constant current of air, which oxydates the other metals. The metallic particles thus oxydated are collected upon the surface of the melted copper, in the form of dross; which is removed from time to time, in order to expose a fresh surface of the liquid metal to the action of the current of air.

By the foregoing account it appears that the complete reduction of the copper is altogether a very tedious process; and, from the obstinacy with which the sulphur adheres to the metal, it is often a very difficult process also: and this will account for the difference observable in the copper of commerce; which in some instances possesses the metallic character in a much higher degree than in others. Thus it is found that the copper employed in sheathing ships sometimes lasts a much longer time than it does at others. The defect may often be owing to want of attention during the reduction: in some cases it may depend upon the nature of the ore.

Copper pyrites is very abundantly met with in different parts of this kingdom: particularly in Anglesea and Cornwall.

When this ore contains a very small proportion of metal, it is often employed for extracting the sulphur principally; which is done by roasting it in chambers communicating with flues, in which the sulphur separated by the heat is collected. The roasted ore is afterwards washed for the purpose of extracting the sulphate of copper that has been formed during the process; the water holding this salt in solution is collected; pieces of iron are thrown into it, on which the copper is precipitated in a metallic form; which being collected is called cement copper, or copper of cementation. This process has been already explained under the head of native co per*.

Grey Copper Ore.

Mine de *cuivre antimoniale;* of de Born.

Mine de *cuivre* grise, tenant *argent;* of de Lisle.

Cuivre gris; of Haüy.

Fahlertz; signifying *grey* ore, according to Wa lerius.

It is very brittle.

It is of a grey iron colour, and very considerabl lustre.

Reducible by the blowpipe.

Specific gravity 4,86.

Primitive form, the regular tetrahedron. Its secondary forms are in general slight modifications c the primitive.

Grey Copper Ore of St. Andreasberg.

Lead	34
Copper . . .	16
Antimony . . .	16
Iron	13
Silver	2,25
Sulphur . . .	10
	91,25 *Klapr.*

This ore is often accompanied with copper pyrites with a thin incrustation of which its crystals are sometimes entirely enveloped.

---

* Vid. p. 100.

The tetrahedral form of the crystals of grey copper is almost alone sufficient to distinguish it from those minerals, for which it is liable to be mistaken.

Under the head of grey copper M. Haüy gives the analysis of two other metallic ores, called *grey* and *white* silver, with which it has occasionally been confounded.

Grey Silver of Kremnitz, in Hungary.		*Grey silver of Loanzo, in Piedmont.*	
Antimony	34,09	Antimony	36,9
Copper	31,36	Copper	29,3
Silver	14,97	Iron	12,1
Iron	3,30	Silver	0,7
Sulphur	11,50	Sulphur	12,7
	95,22 *Klapr.*		91,7 *Napione.*

White Silver of Freyberg, in Saxony.

Lead	48	Lead	41
Silver	20,40	Antimony	21,50
Antimony	7,88	Silver	9,25
Iron	2,25	Iron	1,75
Sulphur	12,25	Sulphur	22
Alumine	7	Alumine	1
	97,78 *Klapr.*		96,50 *Klapr.*

With respect to the foregoing analyses it may be observed, that in that which is called grey copper, both copper and lead are present: in the grey silver, copper is present; but lead is not: in the white silver, lead is present; but copper is not.

It appears from the history of the mineral which was the subject of the first of the preceding analyses, that its primitive form is the regular tetrahedron: the primitive form of copper pyrites is also the regular tetrahedron: and it is remarked, that these are the only species of minerals in which that primitive form is found; and that these two species very frequently accompany each other. Hence M. Haüy is induced to conjecture that they are more nearly allied than by their chemical analysis they appear to be.

CARBONATE OF COPPER.

BLUE CARBONATE OF COPPER.

Κύανος αὐτοφυής; of Theophrastus.

Cæruleum Montanum; of Wallerius: this and the translated term "Mountain Blue" are applicable to the earthy form of blue carbonate of copper.

Azur de cuivre, ou *fleurs* de cuivre *bleues;* of de Lisle: these terms are applicable to the crystallized varieties, the colour of which is generally more beautiful than that of the earthy.

Easily scratched by the knife.
Soluble, with effervescence, in nitric acid.
Reducible by the blowpipe.
Specific gravity 3,60.
Primitive form, an octohedron; the surfaces of which are scalene triangles.

Oxyd of Copper . . .	77
Carbonic Acid	20
Water	2
	99 *Pelletier.*

The crystallized varieties of this substance are of a uniform deep blue colour: the earthy varieties are generally pale, in consequence of being mixed with other substances; and in this state blue carbonate of copper is commonly called "mountain blue."

The substance called Armenian stone by the ancients is either quartz or a calcareous carbonate, coloured by earthy blue carbonate of copper.

A very beautiful form of blue carbonate of copper consists of an aggregation of delicate fibres, radiating in every direction from a common centre.

GREEN CARBONATE OF COPPER.

Malachite: this term is applicable to the fibrous a mamillated varieties. Baccius derives the wo malachite from μαλάχη, "malva," the "mars "mallow;" the colour of which green carbona of copper resembles. The Greek word is som times corruptly written μολόχη: whence Plir has derived the term molochites. "Non tran "lucet molochites, spissius virens et crassiu "quam smaragdus, a colore *malvæ* nomine ac "cepto*."

Ærugo nativa; of Wallerius.

Mountain Green: this and the preceding name ar applicable to the earthy varieties.

Χρυσοκόλλα; of Theophrastus†: this answers to th

---

[*] Nat. Hist. lib. xxxvii.

[†] There were two substances to which the ancients gave the name of chrysocolla; one, an artificial preparation made use of in soldering other metals to gold; another, the natural form of copper now under consideration. As applied to the first of these, the term has an active signification; and expresses the power the substance possessed of uniting metals to *gold*, in the same manner as *glue* unites other substances: as applied to the last, it has a passive signification; and implies that the substance so called was "glued in gold," or, as it would be expressed in modern language, "set in gold."

In the first of these significations the term has been transferred to the salt called borax*; and, as far as its use is considered, not

[*] Vid. p. 11.

malachite of the moderns; and sometimes to the earthy variety called mountain green.

improperly: but the substance employed by the ancients in soldering gold, though analagous in its properties, was different in its composition from borax.

The other signification of the term does not seem to have been always duly considered: for though applied to green carbonate of copper, as it was also applied by the early natural historians, its application has been sometimes explained by adding, that it was the substance employed by the ancients in soldering gold; a property which it never could possess.

The difficulty in understanding the right acceptation of the term ceases, upon considering the substance in question as a gem; which, being highly valued, was much worn, and consequently often set in gold. It would be endless, were it of sufficient importance, to produce quotations in proof of the peculiar estimation in which gems of a *green* colour were held by the ancients: but there is a passage in Theophrastus which so directly illustrates the passive signification of the word χρυσοκόλλα, that it will be worth while to consider it.

In speaking of the Σμάραγδος and Ἴασπις, which are both of them of a green colour, he says, οἷς δὲ εἰς τὰ λιθόκολλα χρῶνται εἰσὶ μικροί[*]. It will hardly be supposed that the word λιθόκολλα implies that these emeralds and jaspers were used for cementing stones together; and the only signification that remains, at the same time the most appropriate, is, that they were used for ornamental jewellery; being set or *cemented*, as precious *stones* commonly are, in some other substance. So, in the conclusion of the Trachiniæ, Sophocles uses the expression χάλυβος λιθοκόλλητον στόμιον; which may be interpreted, "the bit of a bridle set "with precious stones."

---

[*] Pag. 396.

Easily scratched by the knife.

Soluble, with effervescence, in nitric acid; but not readily as the blue carbonate of copper.

It is not so easily reduced by the blowpipe as tl blue carbonate of copper.

Specific gravity varies from 3,57 to 3,64.

It never occurs in a distinctly crystallized form.

Oxyd of Copper . .	58
Oxygen	18
Carbonic Acid . . .	12,5
Water	11,5
	100,0 *Klapr.*

The difference between blue and green carbonat of copper has not been accurately ascertained; bu there is reason to suppose that, in the green carbo nate, the copper is combined with a greater propor tion of oxygen than in the blue.

It occurs in three different forms; which it will b convenient to speak of separately.

Loose fibrous green Carbonate of Copper.

Mine de cuivre verte *soyeuse* and *satinée*; of de Lisle.

Cuivre carbonaté vert *soyeux*; of Haüy.

Nothing can be more expressive of the delicate appearance of this variety of copper than the epithets made use of by De Lisle and Haüy: the lustre of the fibres corresponding very closely with that of silk or satin. When the fibres are too delicate to be separately visible, they have the appearance of very fine velvet. Their colour is usually a dark green, and always very uniform. They are generally disposed in radiating fasciculi; and are accompanied with other ores of copper, and with compact brown iron stone.

In proportion as the fibres become more closely aggregated this variety approaches to the state of the following.

Compact fibrous green Carbonate of Copper.

Compact malachite.

This variety usually occurs in masses having a mamillated surface, like a stalagmite; and commonly made up of distinct concretions irregularly united. These concretions are composed of layers or strata, which are neither uniform with respect to their thickness, or their relative position: upon the whole however they are concentric with one another, although their direction is often wavy. The substance of them is transversely striated; and the colour of some of the strata is much more intense than that of others. From this variety of character in a great measure arises the beauty of polished specimens of malachite; and that beauty is greatly heighthened by the delicate polish of which the substance is susceptible, and by the silky lustre which is apparent in even its m compact forms.

The external surface of compact malachite is of dull; as if it were covered by a thin pulverulent s stance, analagous in its appearance to what is co monly called the bloom of some kinds of fruit.

This variety of malachite is found in similar situ tions with the preceding: by far the most beauti forms of it come from Siberia.

Mr. Jameson says, that M. Patrin saw at Peter burg a plate of malachite, about thirty-two inches lo and seventeen broad, which was valued at twen thousand livres.

It is used in the arts for ornamental jewellery; an sometimes, when pulverized, as a pigment.

In a vein of malachite, in the most eastern part Siberia, a mineral is met with that has sometime been mistaken for the emerald; and sometimes, for crystallized variety of the green carbonate of copper.

M. Haüy, who has given the name of *dioptase* t this mineral in consequence of a peculiar reflexion o light in its interior, describes it under the followin characters.

It scratches glass with difficulty.

It conducts the electric fluid under common circum stances: if insulated, it acquires the resinous o negative electricity.

Reducible by the blowpipe, with the addition of borax, to a metallic state: without the addition of borax its colour is merely changed to a brown.

Specific gravity 3,3.

Primitive form, an obtuse rhomboid; the plane angles of which are 111^{d} and 69^{d}.

Oxyd of Copper . .	28,57
Silex	28,57
Carbonate of Lime .	42,85
	99,99 *Vauq.*

It may be distinguished from the emerald by its inferior degree of hardness and specific gravity; and by its property of conducting the electric fluid.

Earthy green Carbonate of Copper.
Mountain green.
Cuivre carbonate vert *pulverulent;* of Haüy.

This variety bears nearly the same relation to malachite, that the earthy blue carbonate of copper or mountain blue bears to the crystallized forms of the same substance. It is met with in similar situations with malachite. Mountain blue and mountain green are often found in the same specimen; and Theophrastus seems to allude to a natural mixture of this kind in the following words: Κυανὸς αὐτοφυὴς ἔχων ἐν ἑαυτῷ χρυσοκόλλαν *.

---

* P. 396.

It appears from a passage in Suetonius, that this pulverulent form of green carbonate of copper was, together with cinnabar, employed by Caligula on a particular occasion, in ornamenting the arena of the circus. "Edidit Circenses ludos—quosdam autem "præcipuos, *minio* et *chrysocolla* constrato circo*."

General distinctive Marks of the Three preceding Varieties.

Green carbonate of copper is distinguished from green oxyd of Uranium by its fibrous form; and by its effervescence during solution in nitric acid: from phosphate of lead, by its silky lustre; and by the deep green colour of its powder; the powder of phosphate of lead being yellowish green: from muriate of copper, by its effervescence during solution in nitric acid: from arseniate of copper, by the same circumstance; besides which, the arseniate of copper emits a strong smell of garlick under the action of the blowpipe, which the carbonate does not.

---

* Suet. in Vit. Calig. cap. 18.

MURIATE OF COPPER.

This variety of copper has only yet been met with in America; near the confines of Peru and Chili. It occurred first in the form of sand: it has since been met with of a compact texture.

It is of an emerald green colour.

When thrown into the flame of a candle it communicates to it a colour partly green and partly blue.

Soluble, without effervescence, in nitric acid.

If thrown into a colourless solution of ammonia or hartshorn, it immediately produces a blue colour in that liquid.

Specific gravity varies from 3,75 to 4,43.

	Compact Muriate of Copper.	*Pulverulent Muriate of Copper.*
Oxyd of Copper	73	70,48
Muriatic Acid	10,1	11,44
Water	16,9	18,07
	100,0 *Klapr.*	99,99 *Proust.*

The pulverulent form of muriate of copper, called "green sand of Peru," is found in a small river, which loses itself in a desert that separates Chili from Peru. It was brought into Europe mixed with sand and other earthy particles. The green and blue colours, which it gives to the flame of a candle, sufficiently distinguish it from pulverulent green carbonate of copper: it emits no smell of arsenic upon the application of the blowpipe; and may thus be distinguished from arseniate of copper.

PHOSPHATE OF COPPER.

The natural compound of copper and phosphoric acid has not long been known.

The mineral, of which the analysis is subjoined, is met with near Rheinbreidbach, upon the Rhine; much intermixed with quartz, the matrix in which it is found. From its green colour and striated texture it has been mistaken for a variety of malachite.

Oxyd of Copper	68,13
Phosphoric Acid . . .	30,95
	99,08 *Klapr.*

ARSENIATE OF COPPER.

Olive copper ore; of Kirwan.

It is very easily reduced to powder.

Its most common colour is an olive green; fro which it passes through numerous shades till i becomes completely white.

Emits a strong smell of arsenic under the action o the blowpipe.

Specific gravity 4,28.

It sometimes occurs distinctly crystallized. The common forms of arseniate of copper often resembl those of malachite; or hematitic iron ore; o when very compact, wood-tin.

Oxyd of Copper	50,62
Arsenic Acid	45
Water	3,50
	99,12 *Klapr.*

Arseniate of copper has hitherto been found only in Cornwall. Its varieties are very numerous, and the gradations from one to another are very delicately marked: but, from its rare occurrence, its history as an ore of copper is not of much importance.

The strong smell of garlick, and the white arsenical fumes emitted from this substance during the application of the blowpipe, readily distinguish it from green carbonate and green muriate of copper; and from green oxyd of uranium. It is not likely to be confounded with other minerals.

LEAD.

NATIVE LEAD.

The existence of native lead has not yet been sat factorily ascertained; and its ores are so easily r duced, and have been so commonly worked in ages, that great caution would be requisite in ex mining local circumstances, in order to determi whether a specimen, supposed to be native, we really so; or only a portion of an ore that had be smelted at some former period.

Particles of metallic lead have been found in porous lava of the island of Madeira; but the pec liarity of their situation may serve to explain the presence.

NATIVE OXYD OF LEAD.

This is not a common ore of lead, and differs ve little in its external characters from earthy carbona of lead: so that it does not admit of an accurate d scription. M. Haüy doubts its existence altogethe and says that the substances which have been denom nated native oxyds of lead are really earthy forms of native carbonate of lead. Brogniart however cites an analysis of a metallic ore by Vauquelin; in which, though the lead is not the principal constituent part, yet it certainly is in the state of the simple oxyd, and not combined with carbonic acid.

Oxyd of Iron	39
Oxyd of Arsenic . . .	38
Oxyd of Lead	22
	99

A proof that carbonic acid is not present in this ore is, that it does not effervesce with acids.

SULPHURET OF LEAD.

Plumbum *sulphure* mineralisatum, et *argento* mixtum; of Wallerius.

Galena.

Potters' lead ore; being used occasionally in giving a glaze to earthen ware.

It is very brittle.

Divisible, in general, into fragments approaching to a cubic form.

Structure commonly laminated, and often in a great variety of directions; sometimes striated; and sometimes granular.

In colour and lustre it exactly resembles metallic lead before it has been tarnished by exposure to air.

Specific gravity 7,58.

Primitive form, the cube. Its common crystallized forms are modifications of the cube and octohedron.

Its constituent parts vary according to the following proportions in a hundred:

Lead . .	60	to	85
Sulphur .	15	to	25
Silver . .	0,16	to	7,50

Sulphuret of lead is met with in very great abundance in all parts of Europe; and in no place perhaps more abundantly than in England, notwithstanding the great length of time during which the mines have been worked: and they appear to have been worked antecedently to the arrival of the Romans. Pliny, in speaking of the ores of lead, says, "nigrum plumbum in Hispania totasque per Gallias "laboriose eruitur: sed in Britanniæ summo terræ "corio adeo large, ut lex ultro dicatur, ne plus certo "modo fiat [*]." The epithet *nigrum* is used in order to distinguish the metal in question from tin, which at that time was very commonly called plumbum *album*.

A great proportion of the lead of commerce is obtained from this ore; which is first roasted, in order to dissipate the sulphur, and then mixed with the necessary quantity of coke or charcoal, and reduced in a common furnace. The lead, which remains after the operation of roasting, is in an oxydated state: the coke or charcoal, with which it is mixed in the furnace, decomposes the metallic oxyd; and, combining with its oxygen, flies off in the form of carbonic acid gas, while the lead is reduced to a metallic state, and sinks to the bottom of the furnace. The melted lead, after it has been withdrawn from the furnace and received into the bason placed beneath, presents a singular appearance in consequence of exposure to the air: for its surface is instantly covered with a thin iridescent pellicle, owing no doubt to the incipient state of oxydation produced by the union of the oxygen of the atmosphere with the metal. The appearance is not unlike that superficial iridescence which is often observable on natural specimens of sulphuret of lead; and which, perhaps, depends on a similar cause; the sulphur having been previously dissipated at the surface of the ore.

---

[*] Nat. Hist. lib. xxxiv. c. 17.

Crystals of sulphuret of lead are generally very distinct: and are often found completely insulated. M. Haüy says, that this is particularly the case with those crystals which have the mixed form of the cube and octohedron; and he adds, that in some countries crystals of this kind, previously rounded by attrition, are used as bullets.

The accidental fracture of most varieties of sulphuret of lead shews very distinctly a crystalline cubic structure; and the substance readily separates into fragments which approach more or less to a cubic form. In some instances there is a broad striated appearance, which is owing to the presence of antimony; that metal being disposed to crystallize in acicular prisms. Other varieties are of a completely granular texture: to these the epithet *steel-grained* is applied; and it is often very difficult to distinguish them by the eye from granular grey iron ore.

Almost every variety of sulphuret of lead contain a greater or less proportion of silver; and the granular varieties are supposed to contain the most. Th silver, after the reduction of the lead, may be sep rated by the process of cuppellation: but in the great number of instances the proportion of silver is n sufficient to repay the trouble and expense of e tracting it: and hence the lead of commerce almo always contains some portion of silver.

A piece of common sheet lead, of a circular for and about the diameter of a sixpence, the weight which is about a hundred grains, will usually affo by the process of cuppellation a globule of sil barely visible to the naked eye.

Where the proportion of silver is sufficient to re the expense of extraction, the process of cuppellat is so contrived that the oxydated lead does not s into the cuppell, but is separated in the form o semi-vitrified mass called *litharge*.

The minerals that usually accompany sulphure lead are sulphate of baryt, carbonate and fluate of lime, and quartz, among earthy substances; copper pyrites, sparry iron ore, and sulphuret of zinc, among metallic substances: the last mentioned substance scarcely ever fails to accompany it.

This ore usually occurs in veins, and detached masses, imbedded in solid strata; sometimes, though rarely, in rounded nodules imbedded in marl or clay. Brogniart mentions an instance of this kind in Silesia: and a similar instance occurs in that mine, near Castleton, where the blue fluor spar of Derbyshire is quarried.

It is mentioned in the preceding volume * that the blue fluor is met with in masses of a brown clay, which partially occupy the natural cavities of the mine above mentioned. In the same clay I met with several irregularly rounded nodules of sulphuret of lead, of about the size of a walnut, covered with an earthy incrustation of a white colour: there was nothing remarkable in their external appearance; but from their weight I was induced to break them, and found them to be sulphuret of lead. The circumstance is mentioned on account of the singularity of the situation in which the lead was found.

There is a peculiar form of sulphuret of lead called *slickensides;* a term expressive of the smoothness of its surface. It is a thin incrustation, which appears to have been deposited on the opposite surfaces of natural crevices; thus forming a narrow vein. The sides of these crevices are barely removed from each other, yet are not actually in contact.

---

* P. 76.

In some instances this vein penetrates to a considerable extent: and its presence is made known to the miner by a crackling noise, which is produced by the blow of a hammer, or sometimes even the slightest scratch of a pick-axe, against the rock in which he is working: and the noise is usually followed by an explosion of the rock, in the direction and neighbourhood of the vein. The cause of this singular effect is not at all understood.

Sulphuret of lead very closely resembles some varieties of sulphuret of zinc; but the metallic lustre of the latter is destroyed by scratching the surface of the ore with a knife, which is not the case with the sulphuret of lead: if both are breathed upon, the or of lead recovers its brilliancy in a moment; the or of zinc, very gradually. Sulphuret of lead is distinguished from plumbago by its greater specific gravity; and by the comparatively faint trace which i leaves on paper: the same marks will serve to distinguish it from molybdena; which is, besides, of soft foliated texture like talc, and has a considerabl degree of flexibility.

CARBONATE OF LEAD.

CRYSTALLIZED CARBONATE OF LEAD.

Minera plumbi *alba, spathosa;* of Wallerius.

Spathose or *sparry* lead ore: applied to those varieties which have a compact crystalline structure, but do not occur in distinct crystals.

White lead ore; of Kirwan.

Glassy lead ore: applied to those varieties which are colourless and transparent.

It is very brittle.

Soluble, with effervescence, in nitric acid.

Has the double refracting power to a high degree.

Easily reduced by the blowpipe.

Specific gravity varies from 6,07 to 6,55.

Primitive form, a rectangular octohedron. Its most common form is prismatic.

Oxyd of Lead .	81,2
Carbonic Acid ..	16
Lime	0,9
Oxyd of Iron .	0,3
	98,4 *Westrumb.*

Carbonate of Lead from Siberia.		*Carbonate of Lead from Leadhills.*	
Oxyd of Lead	67	Oxyd of Lead	77
Oxygen . .	6	Oxygen . . .	5
Carbonic Acid	24	Carbonic Acid	16
Water . . .	13	Water? . .	2
	100 *Macquart.*		100 *Klapr.*

Crystallized carbonate of lead very much resembles crystallized sulphate of baryt: but the former is soon blackened when thrown into a solution of an alkaline sulphuret; while no change of colour takes place in the latter, when thrown into the same solution. Carbonate of lead is, besides, reduced to a metallic state by the action of the blowpipe; which sulphate of baryt is not.

The change of colour that takes place in carbonate of lead, by exposure to the action of an alkaline sulphuret, depends on its more or less complete reduction to a metallic state. If left in contact with the alkaline sulphuret for a few hours, the surface of the ore acquires not only the colour but even the metallic splendour of lead; and carbonate of lead may be distinguished by this change of colour not only from sulphate of baryt, but from almost every mineral with which it is likely to be confounded.

Many natural crystals of this substance are of a black colour, owing perhaps to a change similar to that which takes place in consequence of the action of alkaline sulphurets: the colour in these instances is only superficial.

The double image of an object viewed through transparent carbonate of lead is accompanied with an iridescent appearance, owing to the dispersion of the rays of light. This effect is often observable in the refraction of light by flint glass; and M. Haüy thinks that flint glass derives the property of thus dispersing the rays of light from the oxyd of lead, which is one of its constituent parts.

The colour of crystallized carbonate of lead is usually white or yellowish white: sometimes it has a tinge of green or blue, which is said to be derived from the presence of copper. Occasionally it is colourless and transparent.

In some instances it is superficially tarnished with ochre yellow spots.

This form of lead occurs more commonly than any other, except the sulphuret; but rarely in sufficient quantity to be worked on a large scale. It generally accompanies galena or sulphuret of lead, and ores of zinc.

EARTHY CARBONATE OF LEAD.

Lead *ochre;* of some mineralogists.

There is nothing remarkable in the external characters of earthy carbonate of lead: its name expresses its common appearance; and its colours vary from a dirty white to a deep brown or even black:

when of the last colour it sometimes incrusts the whi sparry carbonate. Its great specific gravity naturall leads to a suspicion of its real nature; and this ma easily be ascertained by the application of the blow pipe.

It occurs commonly in the same situation with th crystallized carbonate of lead; of which the black coloured earthy carbonate appears to be a partially decomposed form.

Molybdate of Lead.

Yellow lead ore.

It is brittle.

Specific gravity 5,48.

Primitive form, a rectangular octohedron.

Oxyd of Lead	64,42
Oxyd or Acid of Molybdena	34,25
	98,67 *Klapr.*

This form of lead is met with at Bleyberg, in Carinthia, in a compact limestone of a yellowish whit colour. It usually occurs in small and rarely transparent tabular crystals; which are obliquely set o their edges, and meet each other in such a manner a to produce a honey-combed appearance. Their colour is a peculiar shade of yellow; not easily described, but very characteristic of the mineral; an by which it is easily recognized. It perhaps resem bles the colour of pale bees wax more nearly than any thing else.

SULPHATE OF LEAD.

Native *vitriol* of lead, of Kirwan; from the vitriolic, now called sulphuric acid, contained in it.
It is very brittle.
Easily reducible by the blowpipe.
Specific gravity 6,3.
Primitive form, a rectangular octohedron *.

Sulphate of Lead from Anglesea.	
Oxyd of Lead	71
Sulphuric Acid	24,80
Water . . .	2
Oxyd of Iron	1
	98,80 *Klapr.*

Sulphate of Lead from Wanlock-head.	
Oxyd of Lead	70,50
Sulphuric Acid	25,75
Water . . .	2,25
	98,50 *Klapr.*

Sulphate of lead was first discovered in Anglesea, disseminated in small single crystals on the surface of a spongy indurated brown ochre. Some of these crystals are transparent and colourless; but many of them are of a yellow colour owing to a superficial ochry incrustation. Their form somewhat resembles an oblique four-sided pyramid: the lustre of the interior is like that of the diamond.

---

* The form of the primitive octohedron does not correspond in this and the two preceding varieties of lead; each having an appropriate character.

The variety from Wanlock-head is crystallized in tabular plates, and possesses the diamond-like lustre in a much more remarkable degree than the preceding variety.

Sulphate of lead is distinguished from carbonate of lead by its insolubility in nitric acid: from molybdate of lead in being more easily reduced by the blowpipe.

PHOSPHATE OF LEAD.

Green lead ore.

Its colour is usually a green, inclining more or less to yellow.

In hardness superior to carbonate of lead.

It is not reducible by the blowpipe to a metallic state; but fuses into a globule which in cooling assumes a polygonal form, somewhat like that of the garnet.

Specific gravity 6,92.

Primitive form, a dodecahedron; the surfaces of which are triangular.

Green Phosphate of Lead
from Freyberg.

Oxyd of Lead	77,10
Phosphoric Acid	19
Muriatic Acid	1,54
	97,64 *Klapr.*

Brown Phosphate of Lead
from Britany.

Oxyd of Lead	78,58
Phosphoric Acid	19,73
Muriatic Acid	1,65
	99,96 *Klapr.*

Yellow Phosphate of Lead
from Wanlock-head.

Oxyd of Lead	80
Phosphoric Acid	18
Muriatic Acid	1,62
	99,62 *Klapr.*

It appears from the preceding analyses that the relative proportions of the constituent parts of phosphate of lead are very uniform in the different varieties; especially of the muriatic acid, the presence of which might have been esteemed accidental but for its constant occurrence.

Phosphate of lead sometimes crystallizes in hex
dral prisms, resembling some of the crystallized for
of apatite or phosphate of lime; from which the g
bule to which it is reduced by the action of the blc
pipe will serve to distinguish it. It may be dist
guished from carbonate of lead by not effervesci
with nitric acid.

Chromate of Lead.

Red lead ore, of Siberia.
Easily scratched by the knife.
It is a conductor of the electric fluid.
Reducible by the blowpipe.
Specific gravity 6,02.
Primitive form, a prism at right angles with its bas
which is a square.

Oxyd of Lead	63,96
Acid of Chrome . . .	36,40
	100,36 *Vauq.*

This is the substance in which the metal calle
chrome was first discovered.

Chromate of lead was originally met with in
mine situated on the eastern ridge of the Oural moun
tains, in about the fifty-third degree of north latitude
It occurred, in distinct crystals, in a vein running i

gneiss or micaceous schistus: the principal vein of the mine was worked for the sake of the gold it afforded, which is contained in a liver-coloured iron ore of a cubic form.

Since that time it has been discovered in the same neighbourhood, in the form of a thin irregular incrustation, on a kind of ochry micaceous schistus; and also, in a crystalline form, in the interstices of a stratified sand-stone.

The colour of this mineral is, in the mass, of a very deep orange red: when powdered it is much paler, with a strong shade of yellow. In Russia it is much used in oil painting, and is very highly valued on account of its durability.

Chromate of lead is distinguished from realgar, which often closely resembles it in colour, by not emitting a smell of garlick upon the application of the blowpipe: from red silver, by the yellow tinge of its powder: from cinnabar, or sulphuret of quicksilver, by the same mark; besides which, cinnabar is entirely volatilized by the action of the blowpipe, whereas chromate of lead is reduced to a metallic state.

Chromate of lead is sometimes superficially covered with a pulverulent or minutely crystallized substance, of a green colour. This is a combination of oxyd of lead with oxyd of chrome; and may by the eye be mistaken for phosphate of lead, or green carbonate of copper: but, if thrown into nitric acid, it commun cates to the liquid an orange red colour; and ma thus be distinguished from both those substances *.

MURIATE OF LEAD.

This is sometimes called a *carbono*-muriate c lead. Its external characters correspond upon th whole with those of carbonate of lead: but its transparent varieties are of a lemon or straw-yellow colour.

Some peculiarities in the crystallization of thi form of lead first gave rise to a suspicion that it wa not a simple carbonate: and this was fully confirme by analysis.

Oxyd of Lead	85,50
Muriatic Acid	8,50
Carbonic Acid; and, perhaps, Water	6
	100,00 *Klapr.*

The artificial muriate of lead contains from thirteen to fourteen parts in a hundred of muriatic acid: the deficiency in the natural substance may be accounted for by the presence of the carbonic acid.

---

* Vid. the article *Chrome.*

TIN.

NATIVE TIN.

The existence of native tin is nearly as questionable as of native lead. A mineral substance was met with some years since, in Cornwall, having some of the external characters of molybdena: it was, in the mass, very brittle; but particles were detached from it, which were malleable, had a metallic splendour, and in every respect resembled tin. Since that time a substance has been met with in France, which at first was supposed to be native tin; but, according to M. Haüy, the situation in which it occurred being accurately examined, there appeared strong reasons for believing that it was an artificial product; though no probable conjecture could be formed as to the means by which it had been conveyed to the spot where it was found.

NATIVE OXYD OF TIN.

Common Tin stone ; of Kirwan.
Reducible by the blowpipe; but not easily.
Sufficiently hard to strike fire with steel.
It is a conductor of the electric fluid.
Specific gravity varies from 6,45 to 6,97.
Primitive form, the cube.

In the present instance it will be convenient to postpone the general history of this ore of tin; in order to offer a few observations on those varieties which are met with in Cornwall, and also on the methods employed in working the mines of that district.

The tin ore of Cornwall is obtained either by mining in the common manner; or by a process called "streaming."

In the first instance the metallic vein, which is there called a *lode*, is traced by *adits* or *levels*, which are apertures driven horizontally into the rock containing the lode; or by *shafts*, which are similar apertures vertically situated.

In the second instance the ore is found already separated from the native lode: and, judging from its appearance and from local circumstances, has been conveyed to its present situation by rivers, or torrents of water long ago dried up.

The stream works of Cornwall are generally situated in the low ground that lies between the adjoining acclivities of opposite hills; and the lowest point of these works is the angle made by the meet ing of these adjoining and opposite acclivities: their surface is a plane, situated at different heights or distances from this angle, and bounded by the sides of the hills between which it is extended. The measure of this distance differs according to the nature of the spot: in some instances it amounts to many yards; in some, only to a few feet.

The tin ore is found always in the lowest part of the works; sometimes in the form of sand, which is usually of a dark brown or black colour; sometimes in the form of pebbles, the size of which, gradually increasing from the smallest particles, is occasionally equal to a large orange.

The space from the surface of the works, to the point where the tin ore begins to appear, is occupied by common sand, and loose earth or clay; deposited without any regularity, and often containing moss, and branches of trees, and bones of men and other animals.

The common miner in reasoning from these appearances is forcibly led to the conclusion, that at some former period a violent rush of water has detached masses of tin ore from the native lode; and washing them away, together with whatever opposed its progress, has deposited these substances in the situations where they are now found: and the extraordinary weight of the ore readily accounts for its being constantly found in the lowest relative situation.

The ore obtained by this process is called *stream-tin*; and, from the pebble form and general appearance of its particles, and the situation in which i occurs, *tin stone.*

In a few situations a variety of tin ore is met with which from its peculiar appearance is called *wood-tin* it occurs in very small quantities in the stream work near St. Columb, and St. Denis; in fragments whic are rarely equal in size to a large hazel nut. Th form of these is often wedge-shaped, or irregularl conical; and they are indistinctly marked with striæ radiating from the apex towards the base: th surface of the base is frequently convex; so that th fragment appears to be, if the term is admissible, th sector of a sphere. The fragments are divided int numerous bands of different dimensions and shad of colour, principally however of a light brow which cross these striæ at right angles.

On the convex surface of some specimens of woo tin small cavities are observable; which appear t have been formed by the impression of pyramid crystals of quartz: in other instances these caviti are of a spherical form; and their dimensions are ju sufficient to make them capable of containing com mon shot: hence specimens of this kind are call " *shot* tin."

Wood tin often resembles some of the varieties brown hematitic iron ore.

Some mineralogists think it probable that wood t has been formed by stalagmitic deposition.

M. Klaproth carefully analysed a hundred grai of stream tin, partly of a dark and partly of a light brown colour, from Alternon in Cornwall. The results were as follow:

Tin	77,50
Oxygen	21,50
Silex	0,75
Oxyd of Iron	0,25
	100,00 *Klapr.*

M. Klaproth considers the variety, of which the analysis has just been given, as the purest form of tinstone: for it exceeded all the other varieties, that he had an opportunity of examining, in specific gravity; and afforded the greatest proportion of metallic tin.

It should be observed, however, that in this instance the analysis was conducted in what is called the *humid* way; in which the substance under examination is first dissolved by appropriate menstrua, and then recovered by precipitation from the liquid holding it in solution: the results are thus obtained with the greatest possible accuracy. A metallic ore analysed in the *dry* way is submitted to the process of reduction, by mixing it with charcoal or coke, and exposing it to the necessary degree of heat: and this is the common method of *assaying* or ascertaining the value of an ore, with respect to its metallic contents.

In a general practical point of view the last must be considered as the best criterion; because the humid method of analysis cannot be adopted in the lar way: and according to this criterion it will appe that the Alternon tin ore does not yield the great proportion of metal.

The following statement affords a comparative vie of the proportion of metallic tin contained in six v rieties of native oxyd of tin; which were assayed in charcoal crucible.

Grs.		*G*
100	of stream tin, from Alternon in Cornwall, sp. gr. 6,97, gave of metallic tin . . .	76
100	of brown crystallized tin stone from Schlackenwalde in Bohemia, sp. gr. 6,76, gave .	72
100	of wood-tin from Cornwall, sp. gr. 6,45, gave	73
100	of crystallized grey tin stone, having some white transparent spots, from St. Agnes in Cornwall, sp. gr. 6,84, gave	74
100	of black stream-tin from Ladock in Cornwall, sp. gr. 6,56, gave	76
100	of light brown acicularly crystallized tin stone from Polgooth in Cornwall, sp. gr. 6,75, gave	77

From the foregoing statement it appears, that the six varieties analysed by M. Klaproth, the B hemian ore contains the smallest proportion of tin. Of the remaining five, all of which came from Cornwall, the wood tin is the least productive of metal; the partly grey and partly transparent variety from St. Agnes is less productive than the remaining three; and the variety from Polgooth is the most productive.

The primitive form very rarely occurs in the crystallization of native oxyd of tin; and many of the secondary forms are liable to the singular modification called by Romé de Lisle a *macle;* in which the crystal appears to have been divided, and the two halves reunited in a reversed direction. To this apparently altered situation of the two halves of the crystals M. Haüy has applied the term "hémitropie;" and the crystals which appear to have undergone this alteration he calls "cristaux hémitropes." He derives this term from the idea that the separated parts have been half turned round, which would bring them to the situation in which they are placed with respect to each other in the crystals in question.

The colour of native oxyd of tin varies from a jet black to a very light brown or even white: some of the lighter coloured varieties have a semitransparency and a peculiar lustre that has given rise to the term "*resin* tin:" the lightest coloured are in some instances completely transparent.

The specific gravity of native oxyd of tin is very remarkable; for it nearly equals that of the met self: whereas the specific gravity of other native o is in general greatly inferior to that of the metals whence they are derived. Thus

The sp. gr.	of Iron	is 7,78	; of the native Oxyd
	of Copper	8,66	. . . .
	of Zinc	7,19	. . . .
	of Bismuth	9,02	. . . .
	of Tin	7,29	. . . very nearly

The situation in which stream tin is met with, it is always found to occupy the lowest part of works, is evidently the effect of the great specific g vity of the ore; and all the operations of the mi connected with the separation of the ore from the r trix, or from the substances accompanying it, hav reference to this character. With this view, when ore is disseminated through granite or any ot rock, these substances are broken into fragments o convenient size, and submitted to the operation stamping; a mechanical process which reduces mass to a minute state of division: and by means water, the course of which is directed over the poun ed ore, the earthy particles are easily separated fr the metallic oxyd; the water washing away the form and conveying them to a distance, while the latter su sides almost immediately on the spot.

Arsenical iron pyrites is often contained in the m trix of the tin ore of Cornwall, and it is custom in that case to submit the ore to the process of roasting previously to its reduction, in order to expel the arsenic. It is afterwards reduced by means of coke or charcoal.

Native oxyd of tin is met with more abundantly in Cornwall than any other part of the world. It occurs there in the form of stream tin; in distinct crystals; and in specks and grains disseminated through granite and other rocks: it is frequently accompanied with earthy chlorite and wolfram. It is not found in many other parts of the world: the principal foreign mines are in Bohemia and Saxony; in Gallicia; in the peninsula of Malacca, and some of the neighbouring islands. It only occurs in primitive rocks; and as its veins are always divided by and never divide other veins, it is concluded that of all metallic substances its formation is the most ancient.

From this ore all the tin of commerce is obtained.

Yellowish red oxyd of tin sometimes closely resembles blende or sulphuret of zinc; but the latter when triturated emits a smell like that from Harrogate water, which the former does not.

SULPHURET OF TIN.

Tin pyrites; from its analogy in composition to sulphuret of iron or iron pyrites.

It is brittle.

Fusible by the blowpipe into a black scoria.

Specific gravity 4,35.

Tin	34
Sulphur . .	25
Copper . . .	36
Iron	2
	97 *Klapr.*

This substance has only yet been found in neighbourhood of St. Agnes in Cornwall.

IRON.

NATIVE IRON.

THE existence of native iron is not nearly so questionable as of lead and tin; though there is still a considerable difference of opinion on the subject. It is said to have occurred in the form of a vein, mixed with iron ore, at Eibenstock in Saxony; and also in the vicinity of Grenoble: but, in the greater number of instances, those specimens, which are preserved in cabinets under the name of native iron, have been detached from insulated masses met with on the surface of the earth. These masses are totally unconnected not only with the neighbouring substances, but with every mineral hitherto discovered; with the exception at least of certain earthy bodies, found under similar circumstances, which will be spoken of at the close of the present subject.

The following account is principally collected from a paper, in the Philosophical Transactions for 1788, written by Mr. Howard.

Mr. Howard mentions three different masses of native iron: one, met with in Siberia; another, in Senegal; the third, in South America: the last mentioned weighs fifteen tons.

A mass of native iron has also been met with in Croatia.

The Siberian native iron was discovered by Pallas: the weight of it was equal to 1680 Russian pounds. According to his account the Tartars consider it as a sacred relic that had dropped from heaven. The structure of this substance is cellular; in which it corresponds with other masses of native iron: many of the cells have remarkably smooth and polished surfaces: some of them are filled with transparent particles of a yellowish green colour; and as these particles correspond in dimensions and form with the cells containing them, and are liable to decomposition, it is presumed that the cells now empty were once occupied by similar particles. The external characters and analysis of this transparent substance have already been given in the preceding volume under the head of Olivin, of which it appears t be a variety *.

The internal colour of the native iron of Siberia i like that of cast iron: it is externally covere with a thin ochry incrustation, or rather simpl a tarnish, of a yellowish brown colour.

It is very malleable; and may be easily cut by th knife.

---

* P. 123.

Specific gravity 6,48; which is much below that of forged iron: but the difference is accounted for by the cellular and porous character of the native substance.

Iron . . .	98,3
Nickel . .	1,7
	100,0

The analyses of other varieties of native iron, except in one or two instances, correspond closely with that of the Siberian.

	Native Iron of Senegal.	*Native Iron of South America.*
Iron . . .	99,5	99
Nickel . .	0,5	1
	100,0 *Mr. Howard.*	100 *Mr. Howard.*

Native Iron of Croatia.	
Iron . . .	96,5
Nickel . . .	3,5
	100,0 *Klapr.*

Native Iron of Kamsdorf in Saxony.	
Iron . . .	92,5
Lead . . .	6
Copper . .	1,5
	100,0 *Klapr.*

In all the preceding instances, except one, the native iron is alloyed with nickel. The specimen in which no nickel was found was part of a metallic vein; met with in the common process of mining: all the others were detached from those insulated masses that have been already spoken of.

It is worthy of observation, that a similar alloy of iron and nickel is constantly met with in those earthy bodies, which are found in equally insulated situations with the masses of native iron already mentioned: and the tradition and account of the origin of the earthy and metallic bodies is the same; for it is asserted that both have fallen from the air.

However improbable this opinion may appear at the first view; yet when we consider that these substances differ in their composition from all hitherto known; and at the same time remarkably resemble each other: that, in very different parts of the world, they are met with under circumstances, which in themselves might lead to the supposition that they had fallen from a great height on the spot where they now are and that the tradition and accounts of those who live in the neighbourhood almost invariably corroborate this opinion: and, lastly, that in one or two instances they have appeared for the first time at the momen of the explosion of a meteor; and have then been o a much higher degree of temperature than they have ever since been, or in their present situation can be when all these circumstances are considered, it woul hardly be a mark of wisdom to disbelieve at least th possibility of such an origin, as that to which they are generally ascribed.

Some have supposed that these masses have been projected from another planet; beyond the sphere of whose attraction they have been carried, by a force which has brought them within the sphere of this. The notion is uncommon, but cannot be called absurd.

Mr. Howard has given an accurate account of these earthy substances in the same Paper which contains an account of the native iron of Siberia.

He says that they are upon the whole distinguished by the following characters:

Their form is irregular.

Externally they are covered with a thin incrustation of a deep black colour; the surface of which is rough, like fish-skin, and without the smallest gloss: this incrustation seems to possess the properties of iron in a low state of oxydation.

Internally they are of a greyish ash colour.

Their texture is granular, and resembles that of a coarse grit-stone.

Small grains of a yellow colour and metallic appearance, not unlike iron pyrites, are irregularly distributed through their substance: these when powdered are black, and are not attracted by the magnet.

Particles of perfectly metallic iron are also found the substance of these stones; but not in su abundance as the last mentioned particle they are completely malleable; are attracted the magnet themselves, and communicate t same property to the stone; of the whole weig of which they constitute about one fiftieth par

The two foregoing substances, together with n merous globular or elliptical bodies which vary in si from that of a small pin's head to a pea, are c mented together by means of a friable earthy su stance of a whitish grey colour.

These stones have no argillaceous smell wh breathed on.

Mr. Howard examined three different varieties these stones; one of which came from the Sienne territory, in Italy; another, from Yorkshire; and t third, from the neighbourhood of Benares, in Indi The foregoing description, though applicable to all i general, is derived from the last; as possessing t most distinct characters.

The first was part of a stone, which, together wi eleven others, fell near Sienna in Italy, on the twelf of July, 1794. They fell in the midst of a viole thunder storm, about eighteen hours after an eru tion of Vesuvius; which mountain is two hundre and fifty miles distant: upon examination they we found to differ from any stone met with in th neighbourhood. Sir. W. Hamilton received a piece, weighing five pounds, which had been detached from one of the largest.

The second was part of a stone, weighing fifty-six pounds, which fell near Wold Cottage, in Yorkshire. It fell on the thirteenth of December, 1795, at three o'clock in the afternoon: the day was mild and hazy. The stone, when found, had penetrated through twelve inches of soil or loose earth; and six inches of solid rock: when first extracted it was warm, smoked, and exhaled a strong smell of sulphur.

The last was part of a stone which fell with many others, one of which weighed almost three pounds, at about the distance of fourteen miles from Benares. It fell on the nineteenth of December, 1798, at eight o'clock in the afternoon. The sky was perfectly serene for many days before and after the fall.

The specific gravity of the stone from	Italy was	3,41
. . . .	Yorkshire	3,50
. . . .	Benares	3,35

Mr. Howard accurately analysed the several component parts of these stones; and obtained the following results:

Analysis of the several component parts of th Benares Stone.

Grs. 16 of the pyritical particles were found to contain

Sulphur	2
Metallic Iron	10,5
——— Nickel	1
Extraneous Earthy Matter	2
	15,5

Grs. 23 of the magnetic particles of metallic iron contain

Metallic Iron	16,5
——— Nickel	6,5
	23,0

Grs. 100 of the globular or elliptical particles contained

Silex	50
Magnesia	15
Oxyd of Iron	34
—— of Nickel	2,5
	101,5 *

Grs. 100 of the intermediate earthy substance contained

Silex	48
Magnesia	18
Oxyd of Iron	34
—— of Nickel	2,5
	102,5

---

* The increased weight in this and the following analysis w ascertained to be owing to the increased oxydation of the irc produced by the nature of the processes to which it was su mitted.

The earthy parts of the Yorkshire and Sienna stones gave nearly the same proportion of oxyd of nickel as that of Benares: and though the pyritical and magnetic particles could not be subjected to accurate analysis, they each gave abundant traces of the same metal.

From a comparison of all the preceding analyses it appears, that, with one exception, native iron invariably contains nickel; as do also the metallic particles of the stones above described.

The globular particles of the last mentioned substances also contain nickel; but in an oxydated state: and oxydated nickel is found in the globular transparent substance contained in native iron*. The other constituent parts are the same in both; and only differ in their proportions.

If therefore you suppose the metallic particles of the stones, or the globular earthy particles of the native iron, to be increased in quantity; the latter at the same time losing their transparency; the native iron and stones would approach nearly to the same state: and, from the above data, Mr. Howard conjectures there may be a natural connexion between the two substances; and that both have been deposited from meteors.

---

* Vid. vol. i. p. 123.

NATIVE OXYD OF IRON.

This occurs under a very great variety of forms some of which are distinctly crystallized, with a perfectly metallic splendour; others have an aspect and texture completely earthy: and there is every possible intermediate modification of splendour, form, and texture. The different varieties will be arranged as nearly as possible, according to the degree of oxydation of the iron; beginning with those which are nearest the metallic state.

Magnetic Iron Ore.

Common magnetic iron stone; of Kirwan.

Native magnet: applicable particularly to the amorphous granular varieties.

It is not malleable.

Of a grey colour, and dull metallic lustre.

The colour of its powder is black.

All the varieties are attracted by the magnet; and some have the attractive power of that substance: the first, according to Mr. Kirwan's suggestion, may be called *passively*, the last *actively* magnetic.

Specific gravity varies from 4,24 to 4,93.

Primitive form, the regular octohedron.

Iron	85	to	76
Oxygen	15	to	24
	100		100 *Kirw.*

The primitive crystalline form occurs very frequently in masses of schistose chlorite, and in rocks of serpentine: and the ore in general is often found in rocks of the magnesian genus; judging at least from numerous specimens which are said to come from Norway and Sweden; in which the iron is almost constantly accompanied with various forms of asbestus, &c.

The indurated steatite of Corsica contains magnetic iron ore: and an instance of the natural combination of this ore with compounds of the magnesian genus has lately occurred in the neighbourhood of our settlements in New Holland. Specimens of the mineral here alluded to are in the possession of the Rev^{d}. Dr. Clarke of Cambridge; and in a fragment of one of these, which I have lately seen, the iron is accompanied by a substance intermediate in its characters between fibrous jade and asbestus: the lustre of the metallic part resembles that of the ore of tellurium called "aurum "graphicum;" but its colour is much darker.

From the great proportion of iron often contained in the composition of serpentine, &c., a natural connexion between the two substances might be expected: Mr. Jameson however, whose means of information have been very extensive, says that magnetic iron ore does not often occur in serpentine, and never in large quantities.

Some varieties of magnetic iron ore consist of imperfectly defined crystals, either loosely aggregated;

or cemented by a granular form of the same substance: in some the texture is partly granular; and partly compact; and in this case the ore is often mixed with earthy matter: in others, the texture is uniformly as compact as that of jasper. Some varieties are in the form of sand.

This ore of iron is very abundant in Norway and Sweden; and in North America. A mountain in Peru also is mentioned, which consists entirely of magnet.

Magnetic iron ore is reduced to a metallic state by fusion with coke or charcoal; and if the process be carefully conducted it at once produces iron of the best quality. If too quickly fused, its oxygen is not entirely separated; and the iron when at a red heat is consequently often brittle: in which state it is technically called *red-short* iron. Mr. Kirwan observes with respect to this property, that metallic calces, or oxyds, never thoroughly unite with substances in their fully metallic state; hence when iron imperfectly reduced, in which case many of its particles are in an oxydated state, is much dilated, as it is in a red heat the points of contact are too few, and a division or fracture necessarily takes place. He adds, that sulphur in ever so small a proportion, or clay, or any other foreign ingredient, produces the same effect.

Magnetic iron ore affords from fifty to eighty parts in a hundred, of metallic iron; sometimes even more than this.

This may be distinguished from specular iron ore by the black colour of its powder; the powder of specular iron ore having generally a shade of red mixed with black; also, by the readiness with which it is attracted by the magnet; which seldom has much influence on even the smallest particles of specular iron ore. The octohedral form of the crystals of the former variety is also a good distinctive mark, where it is present. It may be distinguished from granular sulphuret of lead by the readiness with which it obeys the magnet.

Specular Iron Ore.

Mine de fer grise ou *spéculaire*, légérement attirable à l'aimant; of de Lisle.

Fer *oligiste*, c'est à dire, *peu abondant en metal*; of Haüy: the meaning of the foregoing epithet is not very clear, at least when explained by the proportion of metal contained in the ore; this amounting sometimes to seventy parts in a hundred.

Sufficiently hard to scratch glass.

When pulverized it is of a black colour, mixed with a shade of red.

Rarely affects the magnetic needle.

Specific gravity varies from 5,01 to 5,21.

Primitive form, a slightly obtuse rhomboid; the plane angles of which are 93d and 87d.

Iron	76	to	70
Oxygen	24	to	30
	100		100

This ore frequently occurs distinctly crystallized: the most beautiful forms of which variety come from the isle of Elba: the interstices of the crystals of the Elba iron are often occupied by a white earthy substance, and by brownish red ochre; and their surface is frequently iridescent, or of a greenish bronze colour. The iridescence of this mineral is peculiarly brilliant.

The specular iron ore of Norway, and Sweden, is often laminated; and the mass is divided by numerous fissures, resembling lines, which cross each other obliquely so as to leave rhomboidal interstices: these lines are parallel to the primitive crystalline form of this variety of iron. Sometimes the laminæ are curved: at others they insensibly graduate into radiating acicular prisms.

A variety of the form last mentioned occurs in irregular nodules, imbedded in masses of brownish red ochry clay, near Totness in Devonshire. When reduced, it afforded nearly seven tenths of metallic iron.

A delicately crystallized form of specular iron occurs in the hematitic iron ore found near Bristol: the form of the crystals is usually lenticular, but so much flattened as to appear merely laminar: they accompany pyramidal crystals of completely transparent quartz; and these crystals often appear black in consequence of the colour of the specular iron placed under and seen through them.

This ore of iron reduced to grains is commonly employed, instead of sand, in drying ink. Sometimes it occurs in small scales resembling mica; and is then called iron *glimmer*, from its shining appearance: in this state it is also called micaceous iron ore.

Specular iron may be distinguished from magnetic iron by the red shade observable in it when pulverized; besides which it is rarely attracted by the magnet: from grey copper, by the red shade of its powder: from granular sulphuret of lead, which it often resembles, by the same mark: from wolfram, by its lighter colour and brighter lustre; and by its inferior specific gravity: from dark coloured mica, by its metallic brilliancy and greater specific gravity.

NATIVE RED OXYD OF IRON.

HEMATITE.

Fibrous Hematite.

Red oxyd of iron.

Hématite, ou terre martiale en stalactites; of d Lisle.

It is scarcely ever attracted by the magnet, unless pr viously submitted to the action of the blowpipe.

Specific gravity varies from 3,5 to 5.

Iron . .	71	to	64
Oxygen .	29	to	36
	100		100

The term hematite is derived apparently from tho varieties, which, in consequence of their colour a tubercular form, resemble a mass of coagulated dro of blood: many of these very readily stain with a r colour whatever they come into contact with; and tl is an additional reason for the name.

Judging by the eye alone, from specimens very co monly met with, the formation of hematite has be occasioned by a concentric lamellar deposition roun point or nucleus; in such a manner that the seve concentric laminæ are regularly striated in a radiat direction from the centre to the circumference. The specimens here alluded to are apparently conical portions of a sphere; and, by the deficiency of some of the laminæ nearest the centre, the cone does not terminate in a point, but in a concave surface; the area of which surface is smaller or larger, in proportion as fewer or more of the laminæ contiguous to the centre have been removed.

In consequence of the peculiarity of its structure, some mineralogists suppose that hematite has been stalagmitically formed: and there are instances of a similar structure in other ores of iron, by many indeed also called hematitic, which appears to have been the result of aqueous deposition. In the present instance there seem reasons for supposing that the structure has resulted from a state of igneous fusion; by a process analogous to that so ably elucidated by Mr. Gregory Watt in his observations on the fusion and crystallization of basalt: these observations are more particularly referred to in the Appendix at the end of this volume *.

As the brown colour of many of those varieties, which appear to have been recently deposited from water, is changed to a red by the application of heat; probably in consequence of the decomposition of the water contained in the mass, and the absorption of its oxygen by the metal; they who are inclined to theo-

---

* Vid. Appendix, p. 11.

rize on subjects of this nature may refer the red colour of hematite to a similar cause: and indeed one great use of such speculations is, that they contribute to the purposes of an artificial classification; and thus facilitate our pursuits in the study of natural substances.

It was mentioned under the head of specular iron ore that the crystallized variety, met with near Bristol, often accompanied hematitic iron ore: other varieties of specular iron ore also very frequently accompany hematite; and although the two substances, when possessing their appropriate characters most perfectly, are exceedingly different; yet they insensibly graduate into each other. Thus some of the Cumberland specimens of hematite are of so compact a texture externally, that their surface has a smoothness and splendour scarcely surpassed by the Elba iron; and sometimes indeed they almost appear to be portions of similar crystals, since they have distinctly crystalline surfaces. On the other hand, in the specimens from Bristol above mentioned, the extreme parts have the perfect appearance, one of hematite, the other of specular iron; and the transition from one state to the other advances so gradually as to be imperceptible to the eye. This natural connexion between the two substances seems easily explicable from the similarity in their composition, their nearly equal degree of specific gravity, and the red shade of colour constantly observable in pulverized specular iron ore.

Pebbles of native oxyd of iron, in an intermediate state between specular and hematitic ore, occur in some instances; and on account of their hardness and smoothness are used as burnishing stones, in the enamelling of gold, &c.: hematite itself when sufficiently compact and hard is used for the same purpose. Fibrous hematite is sometimes disposed to separate into masses resembling splintery fragments of wood. In some instances the fibres converge in a curved direction.

Earthy Hematite.

If you suppose a mass of fibrous hematite to have been reduced to powder, and subsequently washed away and deposited in irregular heaps; it would necessarily assume a common earthy texture: if unmixed with other substances it would only differ in form from the preceding variety; but if after having been reduced to powder it were washed away and deposited with earthy matter, it would approach more or less to the state of common red ochre.

The intermediate states between these supposed forms of hematite are very numerous. Where the hematitic particles have been reunited simply, or at least with the admixture of very few earthy particles, the substance would have the characters of what is commonly called red-chalk: specimens of this kind sometimes occur which are composed of numerous slender columns of a basaltic form, closely applied to each other, and sometimes curved in various directions: and this may have happened in consequence of desiccation; as in the case of a mass of common starch.

One variety of earthy hematite, called by Mr. Kirwan "red scaly iron ore," adheres to the fingers with an unctuous feel: it appears in some instances to be an altered state of micaceous specular iron ore; and, according to Mr. Henry, its constituent parts are

Iron	66
Oxygen . . .	28,50
Silex	4,25
Alumine . . .	1,25
	100,00

It is met with at Ulverstone, and several other places on the borders of Lancashire. It affords very good iron; and, as the proportion of earthy matter is small, it requires very little limestone for its reduction. Where the proportion of earthy matter in a metallic ore is large, and of an argillaceous nature, as is most commonly the case, limestone is necessary in the reduction of it, in order to vitrify the earthy particles; lime very easily acting upon other earths so as to convert them into glass: and in the reduction of an ore this glass floats on the surface of the reduced metal, and is called a *slag*. Its colour is usually a brown or bluish green, in consequence of the presence of oxyd of iron; which has the property of communicating a green colour to glass.

Red hematite may be distinguished from compact sulphuret of quicksilver, or cinnabar, in not being volatilized by heat; also in becoming magnetic by the application of the blowpipe.

Brown and *Black Hematitic* Iron Ore.

Specific gravity varies from 3,78 to 4,02.

The term hematite has by custom been extended to those varieties of native oxyd of iron, which, though they want the characteristic colour, possess the fibrous and radiated structure of that species.

The colour of these varieties is generally some shade of brown; occasionally a jet black: the exterior, though commonly dull, has sometimes a remarkable gloss; particularly in the case of black hematitic iron ore.

They have a more decidedly stalactitic character than the red hematite; and often in the same specimen one part consists of numerous columns, or columnar cones, resembling the common calcareous *stalactite;* and another part is of a flat mamillated form, like the common calcareous *stalagmite:* the difference of these two forms of carbonate of lime, with a reference to their origin, has been described in the preceding volume*. If these columns are broken transversely they present a radiated appearance, arising from numerous fibres or lines which regularly converge from the circumference to the centre.

---

* Vid. vol. i. pp. 43, 44.

In some instances the columnar aggregations are very delicate, and in their form resemble that remarkable variety of calcedony which has been compared to an agglutinated mass of the bones of small birds [*]: the columns however are placed with greater regularity in the iron ore; and are nearly parallel with each other. The darker coloured varieties are sometimes covered with an iridescent pellicle; the colours of which are extremely beautiful, and have a splendour completely metallic.

The Forest of Dean and that neighbourhood abound in brown hematitic iron ore; many of the specimens of which are accompanied with a singular compound crystallization of calcareous spar, which has been already mentioned [†].

Brown hematitic iron ore has not yet been submitted to an accurate analysis: it appears to be an oxyd of iron combined with different proportions of oxyd of manganese.

It usually affords from two to three fifths its weight of metallic iron; which upon the whole is of an inferior quality to that obtained from the red hematite: it is preferable for the purpose of making steel, and its value in this respect is supposed to depend upon the manganese contained in it.

---

[*] Vid. vol. i. p. 218.

[†] Ibid. p. 53.

Fibrous brown hematite sometimes closely resembles wood tin; but it is specifically lighter, and by the application of the blowpipe becomes magnetic, which wood tin does not.

ARGILLACEOUS IRON ORE.

In this variety of iron ore, which is very common in this island, the metallic oxyd is intimately mixed with argillaceous, and sometimes with calcareous particles also: the compound has the appearance of indurated clay.

The specific gravity varies from 2,69 to 3,65.

It affords from thirty to forty parts in a hundred of metallic iron: but most commonly not much more than thirty. The iron however obtained from it is of a remarkably good quality.

This is the ore which is worked so extensively in South Wales; in Shropshire; and at Carron in Scotland. Its value is increased by the coal and limestone that usually accompany it: the limestone being necessary for the purpose of vitrifying the argillaceous part*; the coal, for the purpose of reducing the oxyd of the iron.

The first process reduces the metal to that state in which it is called *crude*, or *cast*, or *pig* iron: the first of which terms expresses its imperfectly metallic state; the second, that in a state of fusion it has been received into appropriate moulds; and the third, by a whimsical comparison, the form of those moulds; that is, the melted iron being received into a broad longitudinal cavity, from which numerous smaller cavities branch out at right angles, the whole presents the appearance as it were of an animal suckling a number of its young, lying on each side of it. The iron in this crude state being imperfectly reduced, and having also imbibed a portion of the coaly matter employed in its reduction, is too brittle and too hard for common purposes. In the subsequent process it is thrown into a horizontal furnace, and kept constantly in contact with the fuel by which the furnace is supported: and as the heat is sufficient to soften without melting it, it is kneaded constantly by means of long rakes worked by men from the mouth of the furnace, till by degrees the oxygen contained in it is entirely separated; and the iron in that respect is reduced to a completely metallic state. The increasing toughness of the kneaded mass affords the means of estimating the progress of the operation. But as iron at a high temperature very readily imbibes charcoal, on which property indeed depends the fabrication of steel, the kneaded mass of iron is not yet of its ultimate degree of purity; in consequence of its containing a greater or less proportion of charcoal. This may in a great measure be separated by mechanical force, as hammering and rolling: but in being separated it carries with it a portion of the iron. This compound of the charcoal and iron, which is analogous to the natural mineral called plumbago, is the substance which flies off in the form of brilliant sparks from a piece of iron, of a white or a high red heat, when struck by the hammer on a common anvil; or from those larger masses which have lately undergone the process of reduction, when flattened by the more powerful engine of a foundery.

---

* Vid. p. 175.

Argillaceous iron ore commonly occurs in thin seams or strata alternating with coal and limestone; sometimes in distinct nodules of an oblong oval, or lenticular shape. These nodules are often disposed to separate into two parts; and in this case the surfaces of the divided parts usually bear vegetable impressions; apparently of a species of fern. The form of the nodule generally corresponds with the outline of the impression: it is probable therefore that the substance, of which the impression remains, either was the nucleus round which the ore while in a soft state was deposited; or else, in the general contraction of the stratum in which it occurs, it formed a point of union that held together the adjacent particles, and thus was the cause of the form of these nodules. These impressions are sometimes superficially covered with a thin incrustation of iron pyrites: and sometimes the central part of the nodule consists of compact specular iron ore.

There are different varieties of this ore, which have acquired distinctive names in consequence of the peculiarity of their form; but, as there is no essential difference in these substances, a short description of them will be sufficient.

The *ætites*, or *eagle-stone*, is a hollow nodule containing a kernel of the same substance; the kernel occupying more or less of the cavity. The ancients had an idea that this kind of stone was found in eagles' nests; and hence the term *ætites:* if the cavity contained loose earth it was called *geodes*. But the terms eagle-stone and geode are not confined to these varieties of iron ore; being applied to mineral substances in general of a similar form.

Ball-ore of iron: this is made up of irregularly concentric laminæ. This and the foregoing variety are commonly met with in the argillaceous iron mines of this country.

Pea-ore of iron: this occurs in small spherical grains. It is principally met with in the central parts of Europe. A variety of this ore analysed by M. Vauquelin gave the following results;

Iron	30
Oxygen . . .	18
Alumine . .	31
Silex . . .	15
Water . . .	6
	100

Another variety from Mount Cenis consisted of

Oxyd of Iron . .	30
Silex and Alumine .	20
Carbonate of Lime	50
	100

According to Mr. Jameson, pea iron ore is met with in secondary limestone, and in beds of clay: in the limestone it appears to fill hollows, and the particles are connected together by stalagmitic carbonate of lime, so that the whole mass appears as if composed of distinct concretions.

In Dalmatia it is said to be used by the inhabitants instead of shot.

Lowland Iron Ore.

Meadow lowland ore; and *swamp*, and *morass* iron ore.

Specific gravity about 3.

Its constituent parts, the proportions of which do not seem to have been ascertained, are

Oxyd of Iron
Phosphoric Acid
Alumine
Silex
Vegetable extractive matter, in small quantity.

During the reduction of this ore, which affords about three tenths of metallic iron, the phosphoric acid contained in it is decomposed; and the phosphorus combining with the iron communicates to it the property which has given rise to the term *cold-short;* that is, though malleable when hot, it is brittle when cold.

According to Werner, this species of iron ore is formed in the following manner: "The water which "flows into marshy places is impregnated with a vegetable acid, formed from decaying vegetables, "which enables it to dissolve the iron in the rocks over "which it flows, or over which it stands. This water "having reached the lower points of the country, or "being poured into hollows, becomes stagnant; by "degrees evaporates; and the dissolved iron being "accumulated in quantity by fresh additions of water, "there follow successive depositions, which at first "are yellowish, earthy, and of little consistence; "and this is Morass-ore: but in course of time they "become harder, their colour passes to brown, and "thus Swamp-ore is formed. After the water has "completely evaporated, and the swamp is dried up, "the swamp-ore becomes much harder, and at length "passes into Meadow-ore, which is already covered "with soil and grass *."

---

* Vid. Jameson's Mineral. vol. ii. p. 338.

SULPHURET OF IRON.

Pyrites: this term is derived from the use to which it was formerly applied, of obtaining sparks by percussion, as from the common flint and steel. Pliny mentions this application of pyrites very particularly.

Martial or *Iron* pyrites; to distinguish it from copper pyrites, which it often closely resembles.

Marcasite: according to Wallerius this word is used by the Arabians to express any substance in an imperfectly metallic state, and not easily reduced: and he supposes it may be derived from the Hebrew word " marach," "*flavescere.*"

Loses its sulphur, and becomes red, by the application of the blowpipe.

Almost all the varieties strike fire with steel; with, at the same time, a sulphurous smell.

Specific gravity varies from 4,10 to 4,74.

Primitive form, the cube: some of its crystalline forms appear to be derived from the regular octohedron.

	Dodecahedral Pyrites.	*Cubic Pyrites.*
Sulphur	52,15	52,70
Iron	47,85	47,30
	100,00	100,00 *Mr. Hatchett.*

Radiated Pyrites.

Sulphur	53,60	54,34	
Iron	46,40	45,66	
	100,00	100,00	*Mr. Hatchett.*

Magnetic Pyrites.

Sulphur	36,50	
Iron	63,50	
	100,00	*Mr. Hatchett.*

The substance known by the name of "*piedra* de "los Incas" is a cubic form of iron pyrites; which from its size, and the splendour of its surface, was used by the monarchs of Peru as a mirror. The surfaces of cubic crystals of iron pyrites are in general striated in such a manner, that the lines of any one are at right angles to those of all the adjoining.

Besides its distinctly crystalline forms, iron pyrites occurs in serrated plates resembling a cock's comb: in capillary filaments: in radiating fibrous masses: in all kinds of stalactitic shapes: in the form of small mushrooms: in rounded nodules, which from the roughness of their surface have been compared to mulberries; this roughness being occasioned by the projecting points of small crystals clustered together: sometimes in masses in which the distribution of the several parts presents an appearance similar to some varieties of agate; particularly that called "*fortification* agate *:" and, lastly, in grains loosely aggregated in marl; and in the form of an incrustation on coal and fossile wood.

Sulphuret of iron is disposed to undergo two very different changes by exposure to the air: for either the sulphur is dissipated; or, by absorption of oxygen, it is converted into sulphuric acid.

In the first instance the pyrites gradually loses its metallic splendour; and is ultimately reduced to the state of a brown oxyd of iron: from its colour the decomposed sulphuret is distinguished by the epithet "hepatic." This variety frequently contains gold †, and is consequently called "*auriferous* pyrites;" but the gold is not chemically combined with the other constituent parts of the pyrites: it is simply mixed with them; and therefore as the decomposition proceeds its particles become more apparent. In some masses of sulphuret of iron this decomposition has not penetrated far; in others it has nearly pervaded the whole substance, so that only the central part retains the characteristic colour and lustre of undecomposed pyrites. Some mineralogists are inclined to think that several of the argillaceous ores of iron have arisen from the accumulation of particles of pyrites, decomposed in the foregoing manner; which have been washed away and deposited by water.

---

* Vid. vol. i. p. 224.

† Vid. p. 144.

In the last instance, the acid produced by oxygenation of the sulphur combines with the iron, and forms the metallic salt called sulphate of iron, or green vitriol. Radiated and stalactitically formed masses of pyrites are particularly subject to this spontaneous alteration.

It is not known what occasions the predisposition in the pyrites to undergo these changes. In the change last mentioned Mr. Hatchett thinks it probable that the sulphur in the natural substance is already slightly combined with oxygen, which disposes it to a further absorption of the acidifying principle. The appearances that take place in the pyrites during the formation of the green vitriol have been already described *.

There is no depth to which mining has been carried where iron pyrites is not found: one of its most common appearances perhaps is under the form of cubic crystals imbedded in varieties of slate. The substance of fossile shells, especially of the variety called "cornu ammonis," is frequently pyritical.

The variety called magnetic pyrites does not occur crystallized: its magnetic property depends on the small proportion of sulphur contained in it.

Iron pyrites is never worked as an ore of iron: it

---

* Vid. p. 21.

is principally valuable on account of the sulphur contained in it; which is either separated by means of heat; or, in consequence of artificial processes, is made to undergo that alteration which gives rise to the production of green vitriol.

Iron pyrites may be distinguished from copper pyrites by its greater hardness: from native gold, by its want of malleability.

SPATHOSE, OR SPARRY IRON ORE.

This substance differs not, except in its form and the proportions of its constituent parts, from pearl spar; which has been already spoken of in the first volume *. It is there said that the specific gravity of pearl spar is about 2,8: and that its constituent parts are

Carbonate of Lime	94
Oxyd of Iron and Manganese	6
	100

It is also there said, that when the proportion of metallic matter is sufficient to raise the specific gravity above 3, its pearly lustre is lost: when sufficient to raise the specific gravity above 3,6, it is to be considered as the ore of iron called spathose or sparry. This name is derived from its foliated or laminated structure.

---

* Pp. 56, 57.

	Sparry Iron Ore from Stiria.	*Sparry Iron Ore from Sweden.*
Oxyd of Iron	38	22
——— Manganese	24	28
Carbonate of Lime	29	43
	91	95 *Bergm.*

The iron obtained from this ore is in general of a very good quality, and easily converted into steel: sometimes indeed a part of the reduced metal is in the state of steel upon its first reduction: hence this ore is sometimes called "*steel* ore."

It is rarely met with in England. In the central parts of Europe it occurs in great abundance, and has been smelted for many centuries.

PHOSPHATE OF IRON.

Native Prussian blue: from its resemblance to the artificial substance so called.

This occurs in an earthy form, always in small particles, in beds of clay; also mixed with lowland iron ore; and incrusting turf and peat. It has not yet been accurately analysed.

It principally occurs in situations where organic matter is present in a state of decay; and, from the decomposition of this organic matter, the phosporic acid has very probably been produced.

When first disengaged from the substances in which it is contained it is of a greyish white colour: by exposure to air it becomes blue; probably by absorption of oxygen.

It is found in morasses containing swampy iron ore; and, according to Brongniart, in the cavities of some of the lavas of Mount Etna. When thrown into oil it becomes black; and may thus easily be distinguished from earthy blue carbonate of copper, for which it is liable to be mistaken.

The Turquoise.

Gemma Turcica.

This substance, which, according to Tavernier, is only found in Persia, has hitherto been considered as a fossile bone or tooth coloured by copper: but, by a late analysis of M. Bouillon la-Grange, it appears that its colour is owing to phosphate of iron; and that there is no copper contained in it. The results of this analysis were as follow:

Phosphate of Lime	80
Carbonate of Lime	8
Phosphate of Iron	2
Phosphate of Magnesia . . .	2
Alumine	1,5
Water	6
	99,5

In travelling a few years since through Cornwall I met with the recent tooth of a horse, lying near the foot of a heap of copper ore on the sandy bank of the mouth of a small river: the rain that had fallen on the copper ore had carried away with it particles of copper in the state of green carbonate; which had communicated to the tooth a bluish green colour. As a similar alteration in the colour of particles of bone &c. has often probably been observed in the neighbourhood of copper mines, mineralogists were easily led to suppose that the colour of the turquoise was derived from the same source. It is now known, in consequence of the foregoing analysis, that the colour is owing to phosphate of iron.

Arseniate of Iron.

Specific gravity 3.

Fusible by the blowpipe into a dark coloured scoria; with a copious disengagement of arsenical fumes.

It is commonly met with in distinct cubic crystals.

Oxyd of Iron	48
Arsenic Acid	20
Water	30
Carbonate of Lime . .	2
	100 *Vauq.*

This substance has only yet been met with in Cornwall. When pure it is of a deep olive green with a shade of yellowish brown. There are mixed forms of iron and copper combined with arsenic acid: these are usually of a greenish blue colour.

ZINC.

NATIVE OXYD OF ZINC.

Calamine.

Cadmia; of Pliny. This and the foregoing term are applicable to the earthy forms.

When crystallized it easily becomes electric by heat; and often retains its electricity some hours.

Soluble in nitric acid; and gives a gelatinous consistence to the liquor.

Specific gravity varies from 3,52 to 4,10.

Primitive form, a rectangular octohedron.

Calamine of Derbyshire.		*Calamine of Wanlock-head.*	
Oxyd of Zinc	68	Oxyd of Zinc .	66
Silex . .	25	—— of Iron .	33
Water . .	4		
	97 *Mr. Tennant*		99 *Klapr.*

Earthy calamine occurs in great abundance in different parts of England; sometimes forming an incrustation round crystals of carbonate of lime; sometimes in amorphous masses that have a corroded or carious appearance.

Many of these masses are cellular, and the form of the cells is rhomboidal. Here and there they are filled with calcareous spar, which has also a corroded appearance; or, more properly speaking, the calcareous spar has not yet been removed: for by an examination of different specimens it seems clear that the calamine has gradually taken the place of the calcareous spar; and, having probably been introduced between the laminæ, has given rise to those rhomboidal cells above described.

Oxyd of zinc sometimes penetrates carbonate of lime without destroying its texture; as in the case of the greenish white stalagmite of Derbyshire [*], and of many calcareous crystals [†].

The use of calamine in the composition of brass is very generally known. Aristotle mentions this application of it, and makes a distinction between the compound resulting from the mixture of copper and calamine; and that resulting from the mixture of copper and tin: *Φασὶ τὸν Μοσσύνοικον χαλκὸν λαμπρότατον καὶ λευκότατον εἶναι, οὐ παραμιγνυμένȣ αὐτῷ κασσιτέρȣ, ἀλλὰ γῆς τινος αὐτοῦ γινομένης, καὶ συνεψομένης αὐτῷ* [‡].

Crystallized oxyd of zinc, which is frequently met with in Somersetshire, Derbyshire, and Nottinghamshire, is distinguished from many of those substances called zeolites, in not swelling up into a spongy mass upon the application of the blowpipe: from carbonate of lime, by either not effervescing with nitric acid; or by becoming gelatinous when dissolved in it: from sulphate of lime and sulphate of baryt, by its solubility in acids.

---

[*] Vid. vol. i. p. 46. [†] Ibid. pp. 51. 54.

[‡] Arist. ed. Paris. 1654, vol. ii. p. 721.

Native oxyd of zinc sometimes occurs combined with blue or green carbonate of copper: ores of this kind produce brass by the process of simple reduction; and are consequently very valuable. They are very rare.

A singular form of oxyd of zinc has lately occurred in those mines in Sweden which produce the ore of copper called Fahlertz *. It is principally a combination of oxyd of zinc with alumine; its specific gravity is 4,66; and it is sufficiently hard to scratch glass. It is met with in octohedral crystals of an iron grey colour, imbedded in a rock of the nature of compact talc. It is called *automalite* or *automolite.*

SULPHURET OF ZINC.

Blende and *pseudo-galena:* these terms are applicable to the dark coloured varieties which resemble sulphuret of lead, or galena.

Sometimes phosphorescent by friction; and, according to Bergman, as powerfully under water as in the air.

---

* Vid. p. 115.

Easily scratched by the knife.
Specific gravity varies from 3,77 to 4,04.
Primitive form, the rhomboidal dodecahedron.

Small mamillated Blende from Cornwall.

Oxyd of Zinc	66
Sulphur	33
	99

	Phosphorescent yellow Blende from Saxony.		*Brown laminated Blende from Northumberland.*
Oxyd of Zinc	64		58,8
Sulphur	20		23,5
Oxyd of Iron	5		8,4
Water	6	Silex	7
	95 *Bergm.*		97,7 *Dr. Thomson.*

Black Blende

Oxyd of Zinc	53
Sulphur	26
Oxyd of Iron	12
Water	4
	95 *Lampadius.*

The origin of the term *blende* has been already explained in the first volume *. It is strictly applicable to those varieties only which resemble galena: but has been extended by custom to all. The lighter coloured crystallized varieties have often a resinous transparency and lustre: both these and the black coloured very much resemble crystallized tin ore. The light coloured are said to have the phosphorescent property to the greatest extent.

---

* P. 239.

The commonest form of sulphuret of zinc is compact and laminated, and in its appearance is not unlike sparry iron ore; which it often accompanies: this variety is very easily divisible in the direction of its laminæ; and from it the primitive form may often be mechanically extracted with great facility.

The cause of the phosphorescence of blende is not known: it is sometimes excited by the slightest force.

The variety from Cornwall, of which the analysis has been given above, was contained in a mass of spongy pyrites: it externally resembled mamillated sulphuret of copper; internally it was not unlike a light coloured variety of wood tin. It is a very rare form of blende; and, if the analysis was correct, appears to be the purest natural state of this ore.

Sulphuret of zinc is one of the most common metallic ores; its matrix is very frequently quartz and carbonate or fluate of lime. When roasted, in order to expel the sulphur, it is used instead of calamine in brass-making. It almost always accompanies galena; which it sometimes so closely resembles, that, though the two substances are placed by each others side, the eye can scarcely discern the difference: the distinctive marks have been already given*.

Sulphuret of zinc may be distinguished from most other substances which it resembles by exhaling a sulphurous odour, like that from Harrogate water, when either triturated in a mortar or thrown into an acid.

Carbonate of Zinc.

Many mineralogists do not admit this as a distinct species; and all admit that in external characters it very closely resembles the native oxyd. Its existence however can hardly be questioned by those who are acquainted with the results obtained by Mr. Tennant. He analysed the three following varieties of carbonate of zinc.

	From Derbyshire.	*From Somersetshire.*
Oxyd of Zinc	65	64
Carbonic Acid	34	35
	99	99

From Bleyberg, in Carinthia.

Oxyd of Zinc	71
Carbonic Acid	13
Water	15
	99

---

* Vid. p. 135.

ANTIMONY.

NATIVE ANTIMONY.

IN colour it resembles tin.

It has a remarkably laminated structure.

Fused, and then volatilized in the form of white smoke, by the blowpipe.

Reducible by mechanical division to the regular octohedron; and also to the rhomboidal dodecahedron.

Specific gravity 6,72.

It has been met with in Sweden in a matrix of white carbonate of lime; and in Dauphiny, in quartz; and lately at St. Andreasberg.

Native Antimony of St. Andreasberg.

Metallic Antimony	98
Silver	1
Iron	0,25
	99,25 *Klapr.*

M. Haüy describes the structure of native antimony as more complicated than that of any mineral he has hitherto met with.

Native antimony is sometimes alloyed with a considerable proportion of silver*.

NATIVE OXYD OF ANTIMONY.

White Antimonial ore; of Kirwan.

This was once very generally considered as a native muriate of antimony. M. Vauquelin has lately ascertained its real nature, and found it to consist of the following component parts:

Oxyd of Antimony	86
Oxyd of Antimony, mixed with Oxyd of Iron	3
Silex	8
	97

From its pearly lustre and white colour it may be mistaken for some varieties of the substances usually called zeolites: but it is fusible, even in the flame of a candle; and without the effervescence that accompanies those substances: they, besides, require the heat of a concentrated flame in order to fuse them. The oxyd of antimony is also almost entirely volatilized by the continued application of the blowpipe; which the other substances are not.

---

* Vid. pp. 85, 89.

Sulphuret of Antimony.

Στίμμι; of the Greek authors.
Stibium; of Pliny.
Mine d'Antimonie *grise* ou *sulfureuse;* of de Lisle.
Plumose Antimonial ore: this term is applicable to the varieties consisting of the most delicate capillary prismatic filaments.
Fusible in the flame of a common candle.
It leaves a black trace when rubbed on paper.
Specific gravity varies from 4,13 to 4,51.
Primitive form not yet ascertained.

Antimony . . .	74
Sulphur . . .	26
	100 *Bergm.*

This ore is very commonly met with in different parts of Europe and Asia, and usually occurs in masses, the structure of which is prismatic; the prisms more or less closely aggregated, and diverging from a common centre. In proportion to the delicacy of these prisms, their surface is disposed to be iridescent. The plumose variety, from the close intertexture of its filaments, resembles a piece of soft cloth, or even common tinder; and in this variety the iridescence is particularly apparent.

In general the colour of sulphuret of antimony is like that of steel; and its fresh fracture is remarkably bright. Some varieties are of a yellowish tin colour, and are superficially tarnished.

The size of the prisms of sulphuret of antimony is by no means uniform in all instances; nor their position regular: sometimes larger prisms irregularly aggregated are united as it were by minute prisms crossing from one to the other at different angles.

Sulphuret of antimony sometimes penetrates the substance of sulphate of baryt.

This ore of antimony has been very commonly used in all ages, and in different countries, for the purpose of tinging the hair and eyebrows black.

Prismatic or acicular sulphuret of antimony resembles manganese when of a similar form: the ready fusibility of the former is a good distinctive mark between the two. The sulphuret may be distinguished from native antimony by the black streak which it leaves on paper.

Hydrosulphuret of Antimony.

The red antimonial ore of Mr. Kirwan is a modification of the common sulphuret; containing hydrogen in addition to sulphur: hence its present name. The transition from one state to the other may occasionally be traced in the same specimen.

It is met with in Saxony and Hungary, in acicular prisms; and in a plumose form. Its colour is a deep dull red.

ARSENIC.

NATIVE ARSENIC.

It is very brittle.

Of a light steel grey colour.

When exposed to the action of the blowpipe it emits a strong smell of garlick: as do all its compounds.

Specific gravity 5,74.

Native arsenic is not met with in many situations. It occurs sometimes in concentric laminæ which appear to have been formed round a nucleus of red silver ore. Its metallic lustre very soon tarnishes upon exposure to air. Sometimes it is alloyed with native silver *.

ARSENIC ALLOYED WITH IRON.

Mispickel.

Arsenical pyrites: this term is applicable to those varieties which contain sulphur.

Strikes fire with steel; at the same time emitting a smell like that of garlick.

It is of a tin-white colour.

---

* Vid. p. 86.

Specific gravity varies from 4,79 to 6,52.

Primitive form, a prism at right angles with its base; which is a parallelogram with angles of 103^d 20′ and 76^d 40′.

Arsenic . . .	42,1
Iron	57,9
	100,0

This form of arsenic is very common in the tin mines of Cornwall. The white oxyd of arsenic, which is the white arsenic of commerce, is often obtained from it, by submitting the ore to the process of roasting, and collecting the volatilized oxyd in flues connecting with the chambers in which the ore is roasted.

The alloy of arsenic and iron often contains sulphur; in which case it is more or less of a yellow colour; and is called arsenical pyrites. The proportions of the three substances are very variable: in some instances the sulphur and iron so far predominate, that the arsenic scarcely constitutes a twentieth part of the whole mass.

This ore very much resembles the native alloy of cobalt and arsenic: the colour of the latter has often a faint shade of red, by which it may be distinguished; and its form is a modification of the cube, while that of the substance under consideration is prismatic.

SULPHURET OF ARSENIC.

Native Realgar.

Sandaraca; of Pliny.

Its colour is an orange red; with, sometimes, a slight degree of transparency.

Acquires the resinous or negative elecricity by friction.

Very brittle.

When exposed to the action of the blowpipe it exhales a mixed smell of sulphur and garlick; burns with a blue flame; and emits white fumes: the colour of the flame depends on the sulphur, the white fumes on the arsenic, contained in it.

Specific gravity 3,33.

Primitive form, an octohedron; the surfaces of which are scalene triangles: it is probably the same as the primitive form of sulphur; but as realgar only occurs in minute crystals this has not yet been ascertained.

Realgar of Pozzuolo.

Oxyd of Arsenic . .	90
Sulphur	10
	100 *Bergm.*

The remaining part of the history of this substance will be given under that of the following variety.

Native Orpiment.

'Αῤῥενικὸν, of Theophrastus; by the later Greeks written 'Αρσενικόν.

Arsenicum ; of Pliny.

Auripigmentum: from its golden yellow colour, and the use to which it is commonly applied.

It is frequently of a laminated structure: the laminæ are slightly flexible, but in bending them they break in straight transverse lines.

Colour, a bright pure golden yellow: upon the application of the blowpipe it is changed to an orange.

Its other characters correspond very closely with those of realgar. The constituent parts of both substances are the same: but it is supposed that in orpiment the arsenic is in a higher state of oxydation than in realgar.

This substance, which is the arsenic of the ancients, differs from the substance commonly called arsenic at the present day, in containing a portion of sulphur; and in being consequently of a yellow colour: whereas our arsenic is perfectly white.

That the arsenic of Theophrastus and Pliny was of a yellow colour is evident from the particular description which they give of it. Pliny says that the best arsenic is "coloris in *auro* excellentis:" Theophrastus says that, on account of its resemblance in colour, ochre (ὤχρα) is used instead of arsenic: but the term ὤχρα itself is apparently derived from its yellow colour; and that it was of this colour appears further probable, from its being changed to a red by calcination*, which is mentioned by Theophrastus, and being thus converted into the substance called Μίλτος, which answers exactly to our red ochre. Of sandaraca, which has been used as a synonym for realgar, Pliny says, "melior quo magnis *rufescit.*"

The term Ἀρσενικὸν, from which our word arsenic is derived, was an epithet applied by the ancients to those natural substances, the properties of which were found to be of a strong, and as it were *masculine* character: and as the poisonous quality of arsenic was soon found to be remarkably powerful, the term was especially applied to that form of it which was most commonly met with.

The arsenic of commerce of the present day is in some instances of a yellow colour; and as the ores, from which white arsenic may be obtained, very commonly contain sulphur, the presence of this yellow colour is easily explained: for the orpiment of commerce, which is valuable on account of its yellow colour, is obtained by subliming together either a mixture of white arsenic and sulphuret of iron; or of sulphuret of iron and any mineral containing a considerable proportion of arsenic.

Realgar and orpiment are met with in the cavities of many volcanoes: and in the substance of many primitive rocks. They occur in great abundance in Saxony, Bohemia, and Hungary.

---

* Vid. vol. i. p. 177—179.

Realgar is distinguished from red silver ore, and chromate of lead, by its inferior specific gravity: from cinnabar, by the yellowish red colour of its powder; that of cinnabar being a bright red. The strong smell of garlick, and the white fumes which it emits upon the application of the blowpipe, are in themselves strong distinctive marks between this substance and others with which it is liable to be confounded by the eye.

Orpiment is distinguished from native sulphur by its laminated structure, and by the garlick smell which it emits upon the application of the blowpipe: the last property serves also to distinguish it from yellow mica.

COBALT.

NATIVE COBALT ALLOYED WITH ARSENIC.

Its colour is silver white; sometimes with a faint shade of red.

Exposed to the blowpipe it immediately emits a white fume, accompanied with a strong smell of garlick.

There are two varieties of this natural compound; one having a granular, the other a laminated texture.

The first is called by M. Haüy "arsenical cobalt:" its specific gravity is 7,72: its primitive form has not yet been ascertained; but it is found crystallized in cubes, and octohedrons, and the modifications of these.

The last he calls "grey cobalt:" its specific gravity is 6,33: it often strikes fire with steel, emitting at the same time a smell of garlick: its primitive form is a cube, the surfaces of which are remarkably brilliant.

Grey Cobalt of Tunaberg in Sweden.

Cobalt	44
Arsenic . . .	55,5
Sulphur . .	0,5
	100,0 *Klapr.*

The crystalline forms of this last variety are numerous, but in general very accurately defined. The surfaces of the cubic crystals, like those of the cubic crystals of sulphuret of iron, are striated in three different directions, at right angles to each other.

Cobalt alloyed with arsenic is reduced to the state of the simple oxyd of cobalt by the process of roasting: the oxyd is extensively used in the arts, for the purpose of giving a blue colour to glass, and enamels, &c. During the roasting the arsenic is separated in the state of a white oxyd, and is deposited in flues communicating with the chambers where the ore is roasted. From the nature of the substance deposited, these flues are usually called " poison flues:" and probably from the same circumstance the German miners gave this metal the name of cobalt; which literally signifies an " evil spirit."

The white fumes and the strong smell of garlick emitted from this variety of cobalt, and its property of communicating a blue colour to glass of borax, distinguish it from all other minerals.

Native Oxyd of Cobalt.

This ore, which does not often occur, is of a black colour, and earthy appearance; but if rubbed with any hard substance its surface becomes brilliant: and this is a very good distinctive mark of it.

When pure it is particularly valuable; as already existing in a fit state for the purpose of colouring glass &c. without the necessity of being roasted.

A yellow oxyd of cobalt is sometimes met with, but is more rare than the black oxyd.

ARSENIATE OF COBALT.

Peach blossom ore of cobalt; from its colour.
Red cobalt ore.
Flowers of cobalt.
The colour is a violet red.

It is met with in capillary filaments, and in a pulverulent form: it usually accompanies other ores of cobalt; and is found in white quartz, in sulphate of baryt, and sparry iron ore: sometimes blue carbonate of copper is contained in the same matrix with the red cobalt ore.

This form of cobalt has probably been the result of the spontaneous alteration of the alloy of arsenic and cobalt.

It is distinguished from red antimony &c. by giving a blue colour to glass of borax.

BISMUTH.

NATIVE BISMUTH.

Its colour is yellowish white.
It is brittle.
Structure remarkably laminated.
Fusible in the flame of a common candle.
Its surface is sometimes iridescent.
Specific gravity 9,02.

Bismuth occurs more frequently in a native than in any other form. A dendritic variety is met with in Saxony, which ramifies through the substance of red jasper: polished specimens of this substance are much valued on account of their beauty. Sulphuret of bismuth is often mixed with native bismuth.

NATIVE OXYD OF BISMUTH.

Bismuth ochre; of Kirwan.

This is frequently found on the surface of native bismuth, in the form of a greenish yellow powder. The yellow shade of colour in this oxyd serves to distinguish it from green carbonate of copper; and from oxyd of nickel.

NICKEL.

NICKEL ALLOYED WITH ARSENIC.

Kupfer-nickel; from its red colour, which inclines to that of copper.

Its colour is a reddish yellow; and is one of its most distinctive characters.

Specific gravity 6,62.

This substance is a compound of nickel, iron, and arsenic.

The natural alloy of nickel and iron has already been spoken of under the head of native iron.

Arsenical nickel is distinguished from native copper, by its want of malleability: from bronze coloured copper pyrites, by the smell of garlick which it emits upon the application of the blowpipe.

NATIVE OXYD OF NICKEL.

This is found incrusting the preceding variety, in the same manner as the oxyd of bismuth incrusts native bismuth.

It is insoluble in nitric acid, and may thus be distinguished from green carbonate of copper, and also from oxyd of bismuth.

It has already been said that the green colour of chrysoprase is derived from oxyd of nickel *.

---

* Vid. vol. i. p. 204.

MANGANESE.

NATIVE OXYD OF MANGANESE.

Specific gravity varies from 2 to 4,75.

It sometimes occurs in distinct crystalline prisms of a metallic splendour, and steel grey colour; sometimes in amorphous masses of an earthy texture and brownish black colour, here and there interspersed with irregular veins of a metallic lustre. One variety which is commonly called black wad is inferior in specific gravity to some of the lightest earthy compounds. All the varieties very readily stain the fingers.

Prismatic Oxyd of Manganese.

Oxyd of Manganese	92,75	99,25
Water	7	0,50
	99,75	99,75 *Klapr.*

Earthy Black Oxyd of Manganese.

Oxyd of Manganese	68
Oxyd of Iron	6,50
Silex	8
Water	17,50
	100,00 *Klapr.*

The prismatic oxyd of manganese resembles sulphuret of antimony: the method of distinguishing them has been already given *.

The ore called "black wad," when dried and mixed with one fourth its weight of linseed oil, inflames spontaneously if gently heated: the effect is produced probably by the partial decomposition of the metallic oxyd; its oxygen uniting with the oil, and, in consequence of the degree of heat present, occasioning combustion.

Oxyd of manganese occurs abundantly in Somersetshire, Devonshire, and Cornwall: it is very extensively used in bleaching linen &c.

Ores of manganese may be distinguished from other minerals by the purple colour which they communicate to borax when fused with it by means of the blowpipe.

White and Rose-coloured Ores of Manganese.

Several substances have been met with of a compact stony texture, and of a white, or yellow, or pink colour; in which a very considerable proportion of manganese exists: sometimes united in the state of simple oxyd with silex and oxyd of iron; sometimes with carbonic acid. In their appearance they resemble a compact earthy variety of coloured quartz.

They are sometimes called siliceous ores of manganese.

---

* Vid. p. 202.

MOLYBDENA.

THIS metal only occurs in two forms: in an acid state united with lead[*]; and combined with sulphur.

SULPHURET OF MOLYBDENA.

Its colour is a light leaden grey.

Its structure is laminated; and the laminæ are flexible.

Has an unctuous feel.

Specific gravity 4,73.

Primitive form not ascertained; but supposed to be a prism at right angles with its base, which is a parallelogram with angles of 120^{d} and 60^{d}.

Molybdena	76
Iron	1
Sulphur	23
	100 *Lampadius.*

It occurs in granite and other primitive rocks; accompanied with tin and wolfram.

It is very liable to be mistaken for plumbago: the distinctive marks between the two substances have been already given[*]. It is distinguished from micaceous iron by the black stain that it leaves on paper: from talc, by its opacity and metallic lustre.

---

[*] Vid. p. 139.

[†] Vid. p. 59.

CHROME.

THIS metal, the name of which has been derived from the Greek word χρῶμα, "color," has been so called in consequence of the colour which it communicates to some of those substances into the composition of which it enters.

The emerald for instance owes its peculiar green colour to the presence of this metal in the state of an oxyd[*]. The spinell ruby derives its colour from the same metal in the state of an acid[†]: so also does that orange-red coloured mineral known by the name of "red lead of Siberia[‡]."

---

[*] Vid. vol. i. p. 130.

[†] Vid. vol. i. p. 144.

[‡] Vid. p. 145.

TELLURIUM.

As the alchemists distinguished metallic substances by the same names that the ancients had applied to the planets, the principle was extended in the present instance; and the metal under consideration was named by Klaproth from our own planet the earth, or "tellus."

Tellurium has but recently been discovered; and, as it was met with in some of the ores of Transilvania, it has sometimes been called Silvanite.

In these ores it is united with gold, and iron, and other metals. From the white colour of the alloy in some of the varieties, it has been called "white "gold:" and as at first there were great doubts respecting the nature of the ore altogether, and the state in which the gold existed in it; or whether it was to be regarded as a chemical constituent part; it has also been called "aurum problematicum," and "aurum "paradoxum." Klaproth calls this variety "native "tellurium."

In other varieties the metallic part, consisting of compressed flat prismatic crystals, is so distributed as to exhibit a delineation resembling Turkish characters: and hence the term "aurum graphicum."

Native Tellurium from Fatzbay.

Tellurium .	92,55
Iron . . .	7,20
Gold . .	0,25
	100,00 *Klapr.*

Aurum Graphicum from Offenbanya.

Tellurium . .	60
Gold . . .	30
Silver . . .	10
	100 *Klapr.*

Yellow auriferous Ore from Nagyag.

Tellurium .	44,75
Gold . .	26,75
Lead . .	19,50
Silver . .	8,50
Sulphur .	0,50
	100,00

Auriferous foliated Ore from Nagyag.

Lead . . .	54
Tellurium .	32,2
Gold . . .	9
Copper . .	1,3
Silver . . .	0,5
Sulphur . .	3
	100,0

The specific gravity of the ores of tellurium varies from 5,72 to 8,91. Their colour is upon the whole intermediate between that of tin and of lead; occasionally mixed with a bronze yellow.

The matrix of some of the varieties partly consists of the rose coloured siliceous ore of manganese *.

---

* Vid. p. 215.

URANIUM.

So called by Klaproth, from the Greek word signifying heaven; in order to follow the custom, observed by the alchemists, of distinguishing the metals by the names of the heathen deities.

It only exists in the form of an oxyd, of which there are two varieties: one called "pech-blende," or "pitch-blende," from its resemblance to a variety of sulphuret of zinc of the same name: the other "uran-glimmer," or "micaceous uranite."

PECH-BLENDE.

Specific gravity varies from 6,3 to 75.

It contains more than four fifths of the metal in a low state of oxydation. The substance of pechblende is for the most part compact; here and there indistinctly foliated in an undulating direction. It is often partially incrusted with a pulverulent form of the following variety of a greenish yellow colour. It is distinguished from blende and wolfram in not having the laminated structure of those minerals.

MICACEOUS URANITE.

Micaceous uranite is of a yellowish green colour.
Specific gravity 3,12.
Primitive form, a prism at right angles with its base; which is a square.

In Cornwall it is frequently met with in the form of minute square plates in the interstices of an ochry stone.

It is distinguished from mica by its want of elasticity; and by its solubility in nitric acid: from muriate of copper, for which it has been mistaken, by not communicating a blue and green colour to the flame of a candle.

TITANIUM.

THE origin of the name of this metal may be inferred from what has been said respecting the names of the two preceding.

NATIVE OXYD OF TITANIUM.

Red shorl; and red shorl of *Hungary.*
Titanite.
Scratches glass; and sometimes even quartz.
Colour, a brownish or orange red; with occasionally a degree of metallic lustre.
It has very rarely any degree of transparency.
Specific gravity 4,20.
Primitive form, a prism at right angles with its base, which is a square.
According to the analysis of Klaproth it is a pure oxyd of titanium.

It is met with in granite and varieties of micaceous schistus; also in opaque and transparent quartz: in the last instance the crystals of titanite are often remarkably distinct; and, being at the same time of a delicate prismatic form, and of a bright orange red colour, present a very beautiful appearance. Occasionally these prisms are so minute as to be scarcely visible. They are then commonly called " hair shorl."

In some instances, particularly where they occur in gneiss or in opaque quartz, the crystals are half an inch or more in diameter; and appear as if they had been violently bent after their formation, and sometimes even broken transversely, and the two parts removed to a distance from each other; the interstice in this case being filled up with the substance of the matrix.

Crystals of titanite are longitudinally channelled.

Pulverized red titanite has been used as a colouring substance in the Sèvres porcelain.

Octohedral Titanite.

Octohedrite; of Saussure.

Anatase of Haüy; from the elongated shape of the two quadrilateral pyramids that constitute the common octohedral crystal of this substance.

It scratches glass.

It has only been met with in Dauphiny, in the form of very minute crystals of a bluish black colour and metallic lustre; accompanying the variety of felspar which was formerly called white shorl*.

It may be mistaken for minutely crystallized blende; but it is very considerably harder; and does not emit that peculiar smell which blende does when thrown into an acid.

---

* Vid. vol. i. p. 158.

Menachanite.

So called from the valley of Menachan in Cornwall, where this variety of titanium was first discovered by the Rev^{d}. Wm. Gregor.

It is slightly magnetic.

Specific gravity 4,42.

Oxyd of Titanium . . .	45,25
Magnetic Oxyd of Iron .	51
Oxyd of Manganese . .	0,25
Silex	3,50
	100,00 *Klapr.*

This variety, which scarcely differs in its appearance from black sand, has since been met with in America, and in New Holland.

TUNGSTEN.

THE literal meaning of this word is "heavy "stone." The metal was so called from the great specific gravity of this mineral, in which it was first discovered. It is also called "sheelium;" in honour of Scheele, who first ascertained the real nature of this mineral.

It exists in two natural forms; in one of which it is combined with lime; in the other, with iron and manganese: the first is usually called "tungsten;" the last, "wolfram."

Tungsten.

It may be scratched easily by the point of a knife.

It is commonly of a white or brownish white colour: if powdered and thrown into nitric acid it becomes yellow.

Specific gravity 6,06.

Primitive form, the cube: it is also reducible to an octohedron.

	Tungsten of Sweden.		*Tungsten of Cornwall.*
Yellow Oxyd of Tungsten	65	. .	75,25
Lime	31	. .	18,70
Silex	4	. .	1,50
	100 *Scheele.*		95,50 *Klapr.*

The Cornish variety contained a small proportion of oxyd of iron, and of manganese.

Many of the specimens of tungsten met with in cabinets come from Zinnwalde in Bohemia; and are accompanied with mica crystallized in hexagonal plates, and with smoky quartz. Numerous minute crystals of tungsten sometimes incrust the surface of the latter substance.

Tungsten is also met with in Cornwall; and in Sweden. It usually accompanies tin ore and wolfram.

It was at first mistaken for a white variety of native oxyd of tin; from which it may be distinguished by the change of colour it undergoes when thrown into nitric acid. It is distinguished from carbonate of lead by not effervescing with an acid; and in not being blackened by an alkaline sulphuret: from sulphate of baryt, by its greater specific gravity; and by the yellow colour it assumes when thrown into nitric acid.

Wolfram.

Spuma lupi; of Wallerius: this is a literal translation of wolfram.

It easily yields to the file.

Colour, brownish black; with a degree of metallic splendour that is more apparent in some directions than in others.

Structure laminated.

Specific gravity 7,33.

Primitive form, a right angled parallelepiped.

Acid of Tungsten . . .	67
Oxyd of Iron	18
——— Manganese . .	6,25
Silex	1,50
	92,75 *Vauq.*

This substance was originally mistaken for antimony, which by the alchemists was called the wolf; probably because it acted violently upon, and as it were devoured the base metals, in the process of refining gold: hence arose the term spuma lupi, the word *ram*, which signifies "spuma," being applied commonly by the Germans to substances of a laminated structure.

Wolfram usually occurs in tin-mines.

It has been mistaken for native oxyd of tin, and for specular iron: but its splendour is more decidedly metallic than the former; and less so, than the latter. When pulverized it is of a blackish violet colour; oxyd of tin is of a greyish white.

It is specifically heavier than specular iron in the proportion of seven to five.

APPENDIX.

EARTHY SUBSTANCES.

ROCKS.

GRANITE.

THIS term appears to have been originally derived from the granular texture of the substance to which it was applied; and judging from some specimens called antique granite, that were brought from Rome and are in the Oxford collection, was perhaps sometimes applied to varieties of syenite and grünstein, or green-stone.

A well defined granite, according to the present acceptation of the term, consists of quartz, mica, and felspar; which are all distinct from one another: the addition of hornblende, tourmaline, or garnet, is not understood to alter the genus of the stone; but only to constitute a specific difference. The proportions of these constituent parts vary exceedingly; but the felspar is upon the whole most abundant, and from this in general is derived the predominating colour of granite. According to Saussure the proportion of felspar in Mont Blanc, and the neighbouring rocks, is nearly three fourths: the same rocks scarcely contain any mica; the place of which is supplied by hornblende or steatite; and he reasons from the height of these mountains, which he supposes to have been elevated by subterraneous force from a great depth beneath the surface, that deeply situated granite in general contains very little mica; strengthening his conclusion by the fact that those fragments of granite which are thrown out from volcanoes, and which may be supposed to have come from a great depth, contain very little mica.

Sometimes the constituent parts of granite are very distinctly crystallized, particularly the felspar. This is the case in the granite with which the foot-path of Westminster bridge is paved; which came, according to Mr. Smeaton, from Llanlivery, near Fowey in Cornwall. At other times the crystallization is extremely indistinct; so that it is very difficult to ascertain the real nature of the rock, from its close resemblance to some varieties of the stone which in Scotland is called *whin*. Whoever has travelled in those parts of Scotland which abound with granite and whin, and has directed his observation to this fact, must have had frequent opportunities of verifying it: and, partly in consequence of this great similarity, Dr. Hutton supposes that granite like whin has once been in a state of igneous fusion; and that having been forced up from the deeply seated mineral regions, it has elevated the strata at the same time. Mr.

Playfair, from whom the foregoing observation is taken, adds justly, as it appears, that granite has evidently undergone a change from a fluid to a solid state; as is evinced from the crystallized structure in which some of its component parts are usually found: and Mr. Gregory Watt has rendered it highly probable by the results of his experiments on basalt &c., an account of which is contained in the Philosophical Transactions for 1804, that this fluid state was the consequence of simple heat. He at least has done away one strong argument against the supposition, by shewing that in masses which have been vitrified and cooled slowly, crystallization actually goes on after the mass itself has been consolidated: for as from the mutual impression of the crystallized parts it appeared that in some instances the least fusible were last crystallized, it seemed impossible that this crystallization could have taken place from a state of igneous fusion.

There is a variety of granite called *graphique*, in consequence of its polished surface presenting an appearance not unlike oriental written characters: this appearance is occasioned by the outlines of the crystallized quartz, which is comparatively of a dark colour, intermixed with opaque felspar of a light cream colour.

According both to Mr. Kirwan and Dr. Hutton granite is almost universally the basis on which other rocks, primitive as well as secondary, rest. It rarely contains metallic minerals; but of these principally tin and some varieties of iron ore.

Though extremely hard it is capable of being worked with tolerable accuracy by means of picks and wedges: and, according to Mr. Smeaton, the harder it is the more accurately it can be worked.

Gneiss.

Gneiss is, like granite, essentially composed of quartz, felspar, and mica; but its structure is in the mass schistose, the several laminæ being separated from each other by thin strata of scales or plates of mica: from the joint consideration of its composition and structure it is occasionally called schistose granite, and granitic schistus. The stone of which Mr. Smeaton built the Edystone light-house appears by his description to have been a species of gneiss having a degree of elasticity.

Gneiss appears to be the most ancient rock after granite, being generally placed immediately over it: and, according to Mr. Kirwan, where gneiss is contiguous to granite its quartz and felspar are more apparent; and the micaceous part less predominant: where more distant from granite, the contrary happens.

Of all rocks gneiss is the most metalliferous; and almost every metal has been found in this matrix. The mines of Saxony and Bohemia, and the silver mines of Königsberg in Norway, are in gneiss.

Garnets are very often found in gneiss; and sometimes in very great quantity.

Micaceous Schistus.

Quartz and mica are the essentially constituent parts of this rock; the mica generally predominating considerably. The schistose character of this is much more remarkable than that of gneiss: but the one graduates into the other almost imperceptibly. The laminæ are sometimes remarkably contorted, as if some force had been applied to them when in a soft state.

Micaceous schistus passes insensibly into the state in which it is called *roofing-slate*[*].

Porphyry.

The name of this substance was probably derived from the purple red colour of that variety so commonly met with in Egypt, between the Nile and the red Sea. "Rubet Porphyrites in eadem Ægypto; candi- "dis intervenientibus punctis [†]." The Leucostictos of Pliny is perhaps the same; for so it might be called from the white specks disseminated through its substance: these specks are crystals of felspar, though not often accurately defined. The Syenites and Pyrrhopœcilon of the same author seem also to be the red porphyry of Egypt: the first name is derived from Syene; the last from its red colour and spotted and variegated appearance. "Syenites quem ante "Pyrrhopæcilon vocabant. Trabes ex eo fecere reges, "obeliscos vocantes*." Incompletely quarried obelisks are still to be seen in those rocks which are situated between the Nile and the red Sea. At present the term porphyry is applied to any stone of a compact argillaceous or siliceous ground containing crystals, or fragments of crystals, of felspar.

---

[*] Vid. vol. i. p. 187.

[†] Plin. Nat. Hist. lib. xxxvi.

Some of the remains of ancient sculpture are a porphyry having a very dark green base, with crystallized felspar of a greenish white colour: this is probably the Saxum Thebanum and Ophites of the ancients. No statues of this are remaining; and only a few columns.

Porphyry is rarely if ever metalliferous.

This is one of the rocks which Dr. Hutton supposes to have been once in a state of igneous fusion.

Basalt.

The origin of this term is dubious; and its application is by no means well defined. The word occurs in Pliny, with a description applicable to many substances called basalt at the present day. "Invenit eadem Ægyptus in Æthiopia quem vocant "Basaltem, ferrei coloris atque duritiæ. Nunquam "hic major repertus est quam in templo Pacis; ab

---

* Plin. Nat. Hist. lib. xxxvi.

"Imperatore Vespasiano Augusto dicatus *." He afterwards says that the statue of Memnon which sounded when struck by the rays of the rising sun was of a species of basalt not unlike that in the temple of Peace. It appears from Winkelman that basalt was much employed in ancient Egyptian sculpture.

Dolomieu observes with respect to basalt, that many substances of a different nature so much resemble each other in analysis as well as appearance, that it is difficult to fix the application of the name to any one.

The same observation holds with respect to the whinstone of Scotland.

It will be convenient therefore to consider basalt and whin-stone as synonymous; and to give a separate description of various substances that have been considered as subordinate to these; or, where the substances themselves cannot be ascertained, an explanation of their names.

Basalt, of the Giants' Causeway and of Staffa, &c.

Those natural columns which form the giants' causeway in Ireland, and Fingal's cave in the isle of Staffa, together with the rock on which Edinburgh castle stands, and part of the hill, in the suburbs of that city, called Arthur's seat, are all a very compact variety of that class of rocks called basaltic.

---

* Nat. Hist. lib. xxxvi.

The specific gravity of this basalt is about 2,8.
It is sonorous when struck.
Has a remarkable degree of tenacity.
Often affects the magnetic needle.
It is easily fusible in the heat of a common forge, into an opaque compact black glass.

Basalt of Staffa.

Silex . .	48
Alumine . .	16
Lime . .	9
Iron in a low state of oxydation . .	16
Soda . . .	4
Water, and volatile matter	6
	99 *Kennedy.*

Columnar Basalt of Bohemia.

Silex . . .	44,50
Alumine . .	16,75
Lime . .	9,50
Magnesia .	2,25
Iron in a low state of oxydation . .	20
Soda . . .	2,60
Water and volatile matter	2
	97,60 *Klapr.*

An analysis of a similar kind of basalt by Bergman gave the following results:

Silex	50
Alumine . . .	15
Lime	8
Magnesia . . .	2
Oxyd of Iron . .	25
	100

As the presence of an alkali in a common mineral substance was not even suspected in the time of Bergman; and as the means of analysis were not nearly so perfect as at the present day; it is no wonder that a small proportion of such a constituent part should have escaped him.

Besides the mineral alkali or soda MM. Vauquelin and Klaproth have lately discovered in basalt a small proportion of carbon.

The basalt of the giants' causeway, &c. is upon the whole of a close earthy texture; and of a dark grey colour nearly inclining to black. It often contains minute prismatic crystals of hornblende, which are easily recognized by the lustre of their surfaces: occasionally these crystals bear a considerable proportion to the whole volume of the rock; and in some instances are even in a much greater proportion than the basalt itself. By an increase in the proportion of the crystallized part, basalt of this kind passes into the state of sparry or schistose hornblende; which in the earlier systems of mineralogy is usually denominated "Shorl *en masse*," in opposition to the distinctly crystallized forms; hornblende having often been called shorl.

The fusibility of basalt depends upon the great proportion of oxyd of iron contained in it; and as the iron is but slightly oxydated, and consequently not far removed from the metallic state, it often very sensibly affects the magnetic needle. In the isle of Cannay, one of the Hebrides, a variety of basalt occurs that affects the magnetic needle to such an extent as to have given rise to the term *compass* rock, by which it is usually distinguished.

Basalt of this kind often undergoes a superficial alteration of colour in consequence of the further oxydation of the iron contained in it; changing to a brown with often a slight tinge of green: the latter shade of colour depends probably upon the hornblende; which, though it commonly appears of a black colour when in a compact form, has almost always a shade of green that becomes perceptible when its substance is reduced to powder. Mr. Kirwan has applied the term *ferrilite* to basalt of this kind. This change of colour often extends into the substance of the basalt, and in some instances pervades the whole. Where this happens, it is frequently accompanied by a disintegration of the texture of the basalt: and by some this effect is attributed to the altered state of the iron; by others, to the felspar which they consider as a constituent part of all basalt. The disintegration occasionally takes place in such a manner as to leave numerous spherical masses, which have the appearance of being loosely imbedded in the mouldering substance that surrounds them. These balls often resist the further progress of disintegration; and have occasionally been supposed to be of volcanic origin; and to have been ejected from the basaltic rocks where they occur, which are in that case supposed to be themselves the lava of an extinct volcano: and hence the term pseudo-volcano. That all basalt has been in a state of igneous fusion is highly probable: and it appears also probable from the experiments of Mr. Gregory Watt, that the basalt in cooling crystallized in a confused manner round numerous central points within its substance: that the crystallization radiating from these central points in all directions produced numerous spherical masses; the process of crystallization stopping as soon as the radii of two adjoining crystalline centres had extended sufficiently to come into contact with each other. But as he observed also that these radii did not proceed independently of each other, but advanced periodically by regular steps to points equidistant from the centre; thus forming a radiated and at the same time a concentric structure: he conceives that the disintegration of basalt of this kind, proceeding in an inverted order, from the circumference that is towards the centre, would give rise to the production of those spherical masses: and this opinion is confirmed by the evident appearance of a concentric disintegration that occasionally takes place. Stirling castle stands on a basaltic rock remarkably disposed to undergo the disintegration above described.

The low degree of heat at which basalt melts was once made the ground of an argument against that part of Dr. Hutton's theory which supposes that this substance was consolidated from a state of igneous fusion: for it was argued that in this case basalt would in its characters have resembled the black glass into which by heat it may easily be converted: but the force of this argument has been completely subverted by the results of the experiments of Sir James Hall. By these, now perhaps too generally known to require a particular description, it has been proved, that of the same mass of basalt reduced to a uniform glass, any part will retain the vitreous character if cooled rapidly; and any part if cooled very slowly will resume a texture and appearance so nearly resembling the original rock from which it was detached, that even an experienced eye shall scarcely be able to detect a difference. Certainly there will be no greater difference than might be found between two portions taken from different parts of the same rock.

Nor is the probability of the opinion weakened by the fact that basalt sometimes contains cavities filled with water; as is the case in the interior of the nodules of calcedony met with in the decaying basalt of Vicenza; since, as Sir James Hall has very satisfactorily proved that limestone may be fused, without the escape of the carbonic acid or fixed air contained in it, in consequence of the application of heat acting under a great degree of compression; and that other volatile substances may be prevented from escaping also; there can be no difficulty in supposing that under the same circumstances the volatility of water may be restrained: especially as it is a fact familiar to every one, that the increased pressure of the atmosphere, or pressure in any other form, applied to the surface of water, retards the process of evaporation.

In many instances compact basalt is separated into numerous distinct but irregularly shaped columns, consisting of from three to nine sides. A similar appearance is observable in a mass of clay or starch that has been gradually dried; and in the interior of a mass of block tin: often also in common sandstone that has been exposed to a sufficient degree of heat. So that the simple appearance is explicable on the principles either of the Neptunian or Plutonian theory.

The two most striking instances of this columnar arrangement are the giants' causeway in Ireland, and Fingal's cave in the isle of Staffa. The columns of the giants' causeway rarely consist of more than six sides, and are sometimes separated by veins of red ochre, which in such a situation might be called *lithomarga**: the columns of Staffa often have eight or nine sides. The separate columns of both places are disposed to separate transversely so as to form a flat concave and flat convex surface exactly corresponding with each other: and these transverse fractures sometimes occur so frequently in the same column, that the distance between two of them in many instances does not equal the diameter of the column.

---

* Vid. vol. i. p. 177.

The diameter of these basaltic columns varies from three inches to three feet.

In the general appearance of a mass of columnar basalt there is great regularity; but the regularity of form in these instances is very different from the effect of crystallization, the measure of no angle being fixed. Hence it seems that the effect is to be ascribed merely to the mutual separation occasioned by the contraction of the mass.

Basaltic hills are very common in the south of Scotland; and rise up abruptly in the midst of a country, the base of which is entirely of a different nature: these hills give a remarkable character to the country round Edinburgh and Glasgow.

Basalt or whin being much harder than the sandstone through which it rises, is not so easily worn: and hence, as in the beds of rivers, it often stands up above the level of the surrounding sandstone after the manner of a *dyke* or wall. From this appearance has arisen the term *Whin-dyke*, which is very common in Scotland.

Basalt is never metalliferous: and in the mining district of Derbyshire, which consists of alternate strata of secondary limestone and varieties of amygdaloid or toad-stone, the metallic vein constantly fails at the point where it meets the toad-stone; but continues its direction in the stratum of limestone lying immediately above the toad-stone. If, as Dr. Hutton supposes, the toad-stone has been injected in a state of igneous fusion between the strata of the sandstone, the appearance is so far what we should expect: but it is generally said, that though the vein fails with respect to its metallic contents, it does not altogether fail; but pursues its course, and may be traced, without containing any metallic ore. If this is really the case, it is an appearance that few would attempt to explain.

According to Brogniart a similar failure of the ore, immediately that the vein comes into contact with basalt, has been observed in other instances besides that of Derbyshire.

In consequence of its easy fusibility basalt is sometimes used for making coarse glass vessels; and as a flux for iron ores.

Owing to the low state of oxydation of the iron contained in them, some basalts may be used as a substitute for puzzolana, in the composition of cements that are to be used under water.

Ferrilite.

Specific gravity 2,86.

Silex . . .	47,5
Alumine . .	32,5
Oxyd of Iron	20
	100,0 *Dr. Withering.*

This term has been applied by Mr. Kirwan to a variety of basalt commonly known by the name of Rowley ragg; which is either a corruption of Rowley regis, the name of the place near which it is found; or is given to it in common with many other substances which by the common people are called *ragg*-stones.

The following account of it is taken from Mr. Gregory Watt's paper in the Philosophical Transactions for 1804.

He says it is met with in the south-west part of Staffordshire: that it is easily fusible; of an iron grey colour approaching to black; and that it reflects light from a number of brilliant spots or striæ, some of which seem to be felspar; others, hornblende.

Judging from its colour and its alteration by exposure, the iron, he thinks, is in a low state of oxydation: which is also confirmed by the magnetic property of the mountains from whence it comes; which, according to Dr. Plot's observations, turned the needle six degrees from its proper direction.

Mr. Watt made numerous experiments upon this substance, corresponding with those which had been previously made by Sir James Hall on the different effects produced by the rapid or slow cooling of vitrified whin or basalt; directing his attention principally to the crystallization that took place in the interior. By withdrawing the heat very gradually from the vitrified mass, he found that the hornblende became as distinctly crystallized as in the natural substance; some times, even more so. And he ascertained many very important points as to the nature and process of that crystallization which took place in this mineral substance during its consolidation from igneous fusion; which seem to warrant the following conclusions.

First, that in the order of crystallization of compound minerals it does not necessarily follow that a substance must crystallize as soon as it is cooled down to the point where crystallization usually begins to take place; for if its molecules be separated by another substance that is in much greater abundance, this latter may crystallize first; when, if the proportions were reversed, or even made equal, it would crystallize last.

Again, that in general the ingredient which is most abundant is the first to crystallize; and felspar therefore which is much more fusible than quartz may according to this law crystallize, or in other words become solid, while the quartz still remains fluid: the consequence of which will be that the most fusible of two substances may be impressed by the least fusible; an assumption which till the discovery of the law above mentioned appeared to involve a physical impossibility.

And lastly, that the process of crystallization continues to proceed after the consolidation of the entire mass; a fact apparently as extraordinary as the foregoing, but which is satisfactorily illustrated by the alteration that takes place in glass which has been converted into what is called Reaumur's porcelain: during which process the original texture of the glass becomes perfectly fibrous, although it is clear from its form remaining unaltered that it cannot have been in fusion.

Trapp.

This is a variety of a class of rocks that have commonly been denominated basaltic. Wallerius has named it *Corneus trapezius;* partly from that horny toughness which belongs to it in common with several other minerals called hornstones; and partly from its natural disposition to separate into trapezoidal or irregularly four-sided figures, somewhat resembling steps or stairs; the Swedish word *trapp* signifying a step or stair. Wallerius observes that he should have been inclined to call it Corneus *scalaris*, but for the coincidence between the terms *trapp* and *trapezius* as applicable to the form which its fragments are disposed to assume.

Clink-stone.

When struck by a hammer it sounds like a piece of metal; and hence its name.

It has been found in contact with, but lying above, basalt; with which it corresponds as to the nature of its constituent parts: but the proportion of oxyd of iron is much less, and the proportion of soda much more than it is in basalt.

It is easily fusible into nearly a colourless glass.

Amygdaloid.

Mandelstein, or Almond-stone: from its appearance already described*.

Toadstone, of Derbyshire.

Toadstone of Derbyshire.

Sp. gr. 2,3.

Silex	63
Alumine	14
Carbonate of Lime	7
Oxyd of Iron	16
	100 Dr. *Withering*.

Dolomieu calls the base of this rock a variety of hornstone (*roche de corne*); and the nature of this base is in some measure explained by his application of the term *roche de corne* to a compact dark grey basalt. It appears to be the *wacke* of Werner; the *wacken*, *kragg*, *trap*, and *mullen* of Kirwan.

Its principal external character is derived from the irregularly rounded or elliptic nodules of calcedony, agate, earthy chlorite, zeolite, &c. which are contained in it.

According to Dolomieu amygdaloids may be distinguished from lavas that contain rounded nodules of calcareous spar by the following mark: in lava the calcareous spar is radiated; in almond-stones it is laminated. Mr. Playfair however says that lavas, known to be such, never contain calcareous spar.

---

* Vid. vol. i. p. 248.

When these nodules have been removed, which happens by the process of decomposition, there is often a great difficulty in distinguishing between lava and this variety of basalt.

The term toadstone is particularly applicable to those varieties of amygdaloid in which the nodules are small and numerous; and their colour variegated.

Sienite.

Granitelle; of Saussure.

According to Saussure M. Werner now applies the term sienite to a mixture of felspar and dark green hornblende, or mica. According to Mr. Kirwan he first gave the name of *grünstein* to an aggregate rock consisting of quartz, hornblende, felspar; or, of quartz, hornblende, felspar, and mica: he afterwards called these aggregate rocks by the name of *Sienite* (*Syenite* more properly); that term having already been used by Pliny to denominate a similar substance.

Grünstein or Green-stone.

M. Werner applies this term to a compound of compact felspar and dark green hornblende; the name having been probably derived from the prevailing colour of the hornblende.

Dolomieu observed that the basalt of Egypt passed insensibly into the state of green-stone; and frequent instances of the same kind occur with respect to the basalt of Scotland.

The green colour of this stone is probably owing to oxyd of iron.

Pebble-stone.

This term is applicable to a numerous class of rocks, &c., consisting of pebbles of various sizes and colours; which are irregularly connected together, either with or without an intermediate substance: and it is presumed that the cemented particles are pebbles, or have acquired their rounded form by attrition, from their uniform smoothness.

One of the most striking varieties of pebble-stone very commonly occurs scattered in large masses over the vale of Berkshire: it consists of numerous oval pebbles of reddish black flint, very much resembling raisins when swelled by boiling, cemented together by means of indurated sand of a brownish white colour. The whole appearance of the mass has given rise to the term *plumb-pudding stone* in this country;

and the resemblance that gave rise to the term is so remarkable, that it cannot fail to strike the mind upon the first view. The term has been very generally adopted by foreign mineralogists; who, however, commonly call it simply pudding-stone, or English pudding-stone (*poudinge*, of Brochant; *poudding Anglais*, of Haüy). Foreigners also seem to apply the name to varieties of pebble-stone in general. In the pebble-stone of Berkshire the cementing substance is often so highly indurated, and so firmly adheres to the pebbles, that upon the application of a sufficient degree of force the fracture of the stone is carried on indifferently through the pebbles as well as the cement: in some instances the fracture takes place in such a manner as to leave some of the pebbles half imbedded in the stone, and half projecting from the broken surface; which probably depends, either upon a considerable difference in the hardness of the pebbles, and the cement at those parts; or upon a slighter adhesion than usual between the two.

In some instances the cemented particles are angular fragments of pebbles. Both varieties, when the cement is sufficiently hard and compact, are capable of a very beautiful polish.

With respect to pebble-stones in general, their appearance is as various as can possibly result from a variety in the colour, form, size, and degree, and mode of union, of their component parts. The hardest I ever met with occurs in rolled fragments in the bed of the Eske near Rosslyn castle: it consists of numerous differently coloured particles, some resembling red jasper, very compactly aggregated without any intermediate substance.

In some instances the particles of pebble stone are all of milk white quartz.

Occasionally the aggregation is so indistinctly marked, that it is difficult to determine whether the substance is really a pebble-stone, or owes its appearance to the irregular alteration in colour, &c. of an originally homogeneous rock. In some varieties the component parts are so loosely aggregated, or cemented, that they readily crumble upon the application of a slight force.

Rocks of this genus, being often found interposed between primitive and secondary strata, have been called by Mr. Kirwan *semiprotolites*: this relative situation was particularly observed by Saussure in the Alps. Brochant says that the same remark may be made with respect to the compound rock, called *grauwacke* by the miners of the Hartz: this rock is remarkably metalliferous, and is the matrix of the silver and lead ore of the Hartz; and of the gold of Transilvania. Its name literally signifies grey wacke; but the term is erroneously applied, because this rock is not a variety of that which is called wacke by the Germans; which is a species of basalt.

Grauwacke, according to Brochant *, is a kind of pebble-stone consisting of particles of quartz, and siliceous schistus, which are sometimes as large as a nut, cemented by a substance of an argillaceous nature.

Sandstones.

Sandstone, often also called grit-stone, or simply grit, is to pebble-stone what sand is to gravel or pebbles; and is an aggregation of minute siliceous particles: these are sometimes cemented by an intermediate substance; principally of an argillaceous or siliceous nature: and hence the terms siliceous and argillaceous grit. It occurs very commonly in the northern part of England in regular strata: in the southern part, chiefly in the form of irregular masses imbedded in sand, &c.

In those parts of Derbyshire where coal is found, there are two different strata of sandstone. One of these consists of a large grained sand of a very faint flesh colour, apparently cemented by minute particles of an opaque milk white substance, somewhat resembling earthy felspar: the compound would not be unlike some varieties of the white granite of Cornwall, provided the proportion of that opaque white substance were greater. The other sandstone of Derbyshire is cemented by argillaceous particles: it is of a much smaller grain than the preceding.

---

* Tom. ii. p. 588.

The sandstone of which Windsor castle is built consists of minute grains of quartz simply aggregated. It is found in the form of very large irregularly pebble-shaped masses, imbedded in sand or clay in different parts of Oxfordshire and Berkshire. The neighbourhood of Godstone in Sussex affords numerous masses of stone of this kind: and that place is said to have derived its name from the frequent use of this stone in the construction of churches and religious houses.

Those very large stones that compose the outer circle of Stonehenge are a sandstone of this nature; which is in some places very hard and compact; in others, remarkably friable.

The sandstone of Worcestershire and of the midland counties of England is of a loose texture, and of a red colour. Owing to the looseness of its texture it is easily disintegrated; and hence the sandy soil that is met with in the neighbourhood of Ombersley, Halesowen, and many other parts of Worcestershire, Shropshire, &c. This sandstone is the base of the green glass made at Stourbridge; the iron, contained in it, imparting the green colour. In many instances it passes into the state of a loosely aggregated pudding stone.

The sandstone of the northern part of England and of the south of Scotland is hard, and of a broad schistose structure. In the neighbourhood of Newcastle it is employed for making those circular grindstones so common in all parts of this country. The flags with which the footway of the streets in London are paved are of this sandstone; of which there is a very productive quarry in the neighbourhood of Edinburgh. That quarry is remarkable for affording a very good illustration of the nature of a stratified rock; the seams, or separations of the different strata, being very obvious.

Many sandstones contain minute particles of mica, irregularly disseminated through their substance; or deposited in more than usual abundance between the laminæ. Where the proportion of the mica is considerable, it gives rise to the term micaceous sandstone.

Many of the mountains of Breconshire and Radnorshire are a brownish red micaceous sandstone; the colour owing to the presence of an ochry clay. The disintegration of them seems to have produced that red clay so common in those and the neighbouring counties.

A hard compact sandstone containing turbinated shells occurs in Devonshire, which is employed to a great extent in making the common hand whetstone used for sharpening scythes.

Sandstones which yield readily to the chisel, and hence called siliceous free-stones, are used in masonry. If sufficiently porous they are employed in making filtering stones.

The rock on which Nottingham castle stands is a loosely aggregated sandstone, containing numerous small siliceous pebbles. Similar but larger pebbles are met with, though not so frequently, in the sandstone near Perth.

Sandstone occurs very commonly in the neighbourhood of coal; and, in such situations, frequently contains vegetable impressions.

The sandstone met with at Fontainbleau, which is used for paving the streets of Paris, is remarkable for containing groups of rhomboidal crystals. They are found in cavities of the sandstone, and are supposed to have been formed by the infiltration of particles of calcareous carbonate into the substance of it. It is a very curious circumstance that though the form of these crystals is that of one of the varieties of crystallized carbonate of lime, and is certainly owing to the presence of calcareous matter; yet the proportion of this is not more than one third.

There is a substance met with near Villa-ricca in Brasil, usually called *elastic* quartz: it does not differ much in appearance from a fine grained sandstone; but contains numerous flat shining particles somewhat resembling mica. Its elasticity seems to depend upon the mutual support which these particles afford each other.

According to Klaproth its analysis gave the following results:

Silex	96,5
Alumine	2,5
Oxyd of Iron . . .	0,5
	99,5

Siliceous Pebbles.

It has already been said that the form of pebbles in general is owing to the mutual attrition produced by the action of water. This action is recognized in the following lines of Theocritus:

> Ἐν δὲ μύες στερεοῖσι βραχίοσιν ἄκρον ὑπ᾽ ὦμον
> Ἕστασαν, ἥυτε πέτροι ὀλοάιτροχοι, οὕστε κυλίνδων
> Χειμάῤῥους ποταμὸς μεγάλαις περιέξεσε δίναις*.

It appears from the observations and writings of mineralogists, that numerous pebbles of a siliceous nature are met with in almost every part of the habitable world.

Their characters are various; and in some measure depend on the nature of the rocks and mountains of the neighbourhood: many however appear to have been brought to their present situation from a very great distance; and some are scarcely referable to any existing stratum.

Saussure in speaking of the beds of gravel near the lake of Geneva, says, that they consist of an innumerable variety of pebbles &c.

---

* Id. κβ'. lin. 48—50.

They are met with of all dimensions; from masses the cubic contents of which are several feet, to grains not larger than a millet seed: and, were the term applicable to a substance consisting of particles so small, the finest sand of the sea-shore might be classed under the head of siliceous pebbles; since the same cause has given rise to the form of both, and their chemical nature is almost exactly the same.

The larger masses are in many parts of England called *boulder* stones, a name expressive of the cause of their rounded form: the term *pebble* is in common language applied to those which are smaller than the foregoing, but too large to be used as gravel; and these are very commonly employed for the purpose of paving court yards of houses, and the streets of small towns. Common gravel is too familiar to need any description. Pebbles of the smallest dimensions constitute coarse sand.

The gravel immediately round London appears to consist almost entirely of the black flint met with in the neighbouring chalk strata: the pebbles are in general very uniformly worn, and have to a greater or less extent lost the characteristic black colour of the flint from which they are derived; but sufficiently correspond with it to shew the identity of their nature.

The gravel round about Windsor and Maidenhead consists also, in a great measure, of the flint of the surrounding chalk hills; very much discoloured, but not much worn. It appears however that that part of this gravel which is nearest the surface is not of the nature of flint, but in its texture resembles a highly indurated sandstone: and it is observed that these pebbles are much larger than the flint pebbles; and though considerably harder are much more uniformly rounded. They have probably therefore been conveyed from a greater distance; and judging from their relative situation, for they are found nearest the surface, they have been deposited more recently than the flint. It is worth observing that pebbles of this kind are met with in almost every part of England. I have collected them from very different points along the course of the north road, both on the eastern and western side of the island; from Nottingham, York, Durham, Edinburgh, Lanark, Carlisle, Chester, Shrewsbury, and Worcester: and have observed them in many other parts.

The gravel met with immediately round Oxford consists principally of small siliceous pebbles, many of which are flint, mixed with worn fragments of fossile calcareous shells, and brown iron-stone: the presence of all these substances is accounted for by the nature of the surrounding country; the limestone of that district abounding with fossile shells, and many of the neighbouring hills consisting either of chalk containing flint, or of ferruginous sand containing brown coarse ironstone.

Tripoli.

Specific gravity 2,2.

Silex	90
Alumine	7
Oxyd of Iron . . .	3
	100

This substance was originally so called from the town of the same name in Barbary, from whence it was commonly imported: but the name has been extended to similar substances in different parts of the world. The opinions respecting its nature are various; some supposing it to have arisen from the decomposition of porphyry or jasper; others, from basaltic rocks. Saussure conjectures that it is a very fine sand washed and deposited by water; and Wallerius describes it as a kind of fine sand-stone. Any siliceous substance reduced to a sufficiently minute state of division may be used instead of, and hence is often called, tripoli: this is the case with the rotten stone of Derbyshire.

It is sometimes imitated by calcining and reducing to powder certain varieties of slate.

Lava.

According to Mr. Kirwan this term is derived from the gothic word *lauffen*, to run.

Lava often resembles porous basalt; but it is impossible to define a lava accurately, because not only different volcanoes but even the same volcanoes produce different lavas at different times; the internal fire perhaps taking different directions, and acting on different substances.

Many lavas affect the magnetic needle.

A lava analysed by Bergman gave the following results:

Silex	49
Alumine	35
Lime	4
Oxyd of Iron	12
	100

Many dark coloured lavas become white, in consequence of the neighbourhood of acid sulphureous vapours; for these, acting on the iron and clay contained in the lavas, form sulphate of alumine and of iron; which being afterwards washed away, the lava remains white. Some lavas are naturally white. Lavas often undergo a concentric disintegration after the manner of some whinstones. Dolomieu says that he has seen, in the ruins of ancient Rome, blocks of granite and porphyry undergoing a similar disintegration from the action of the weather.

Almost all lavas undergo disintegration by exposure to air; but the time required for this effect is very different in different instances. Some are decomposed in an age or two: some, not under a thousand years. Hence many occasions of false judgment have arisen with respect to the length of time employed in the accumulation of soils that have been formed by the disintegration of lava. This observation, which Dolomieu first made, has been confirmed by Spallanzani and others: and Spallanzani exposes the errors which Brydone and Count Borch fell into relative to the age of the earth, by computing from the depth of soil which had been accumulated from disintegrated lava; the process advancing by no fixed ratio. Thus Count Borch mentions a lava which flowed in the year 1329, on which soil had accumulated to the depth of eight inches; while on the other hand Spallanzani mentions a lava which rushed into the sea in the year 1320, but still preserves in every part its hardness and sterility.

Those lavas which are the lightest and least vitrified, and at the same time contain the greatest proportion of alumine and oxyd of iron, are the most easily disintegrated; and where the proportions of the constituent parts of a disintegrated lava are such, as to be capable of retaining a just portion of moisture for the longest time, the fertility of the resulting soil is greatest. Nothing can be more fertile than the fields of Catana, and all the base of Etna.

The lava of Vesuvius is used in paving the streets of Naples; and according to Winkelman the streets of ancient Rome were probably paved with the same substance.

Volcanic eruptions do not invariably produce lava.

The volcanoes of Quito, the flames of which are sometimes elevated three thousand feet, have never produced a single drop of running lava. They send forth water, inflammable air, dirt, and clay impregnated with coaly matter. Similar muddy eruptions occasionally take place in other volcanoes also.

Puzzolana.

Pulvis Puteolanus; of Pliny: so called from Puteoli, where it it was found in great abundance.

Puzzolana, so called from Puzzuolo, or Pozzuolo, the ancient Puteoli, is not a disintegrated lava, as some have supposed; but a species of argillaceous earth or stone that has probably been calcined or baked, and then ejected from the volcano. According to Winkelman it is sometimes of a black, and sometimes of a red colour: the black puzzolana, which is the heaviest and contains most iron, is used for constructions under water* at the present day, as it was in Pliny's time. "*Pulvis Puteolanus* mersus protinus fit undis unus "inexpugnabilis lapis, fortior quotidie †."

Neither the black nor the red puzzolana are found in any other parts of Italy than the neighbourhood of Rome and Naples.

---

[*] Vid. the article *Limestone of a light blue colour*, vol. i. p. 30.

[†] Nat. Hist. vol. vi. p. 172. ed. Brot.

Rapillo Nero.

Fragments of black lava are called at Naples rapillo *nero* to distinguish them from fragments of pumice which are called rapillo *bianco.* Winkelman supposes the word rapillo to be a corruption of lapillo: so the old English word *sterre* is derived apparently from stella, by a similar corruption.

Trass or Terrass.

This substance is met with in the vicinity of the Rhine, near Frankfort and Cologne &c.; and is there called *tuffstein,* which may be rendered tufa or volcanic stone. It does not however appear to be a volcanic production, but derived from basaltic rocks. From that part of the Rhine it is commonly imported into Holland, and from thence distributed over Europe. It is much used as a substitute for puzzolana. Artificial terras is made by burning clays or slates that abound with iron, and then grinding them to a fine powder.

Pumice.

The description which Pliny gives of this substance is remarkably accurate: "Non prætermittenda est et "*pumicum* natura: laudatissimi sunt in Melo, Ni-"syro, et Æoliis insulis. Probatio in candore mi-"nimoque pondere, et ut quam maxime spongiosi

"aridique sint, ac teri faciles, nec arenosi in fri-
"cando *."

Pumice is fusible, as might be expected from its origin.

Specific gravity about 0,9.

Silex	77,50
Alumine . . .	17,50
Oxyd of Iron .	0,02
Potash and Soda	0,03
	95,05 *Klapr.*

The following account of pumice is collected almost entirely from M. Dolomieu, and is principally applicable to the pumice of Lipari. He suspects that pumice is a vitrified granite or gneiss; for he occasionally met with particles of mica imbedded in it; and, in a few instances, found even pieces of granite, the characters of which were well defined: and he observes that it cannot like other lavas be referred to the fusion of argillaceous schistus, or porphyry; because it is essential to pumice to contain no iron, which those substances contain in considerable abundance.

He adds, that the kaolin of Alençon, which is a species of granite; the granite of the Pyrenees; and that on which the Czar Peter's statue stands in Petersburg; and also the petuntzé of Limoges, employed in the fabrication of the Sève porcelain, all produce a *white* frit, because they contain no iron: and since this frit might be converted into glass by an increase of heat, he supposes that as the silky filaments of pumice are perfect glass, and contain no iron, the heat of the Lipari volcanoes have acted upon granite: and that other volcanoes produce black or red lava, because in them the heat has acted on schistus, and porphyry &c., which contain iron in considerable abundance. Pumice therefore, according to the foregoing account, may be considered as a loose vitrified lava entirely devoid of iron.

---

* Nat. Hist. lib. xxxvi.

The pores of pumice when observed in the undivided mass are always in the direction of the current of the lava of which the pumice makes a part: in proportion as it is nearer or further from the surface, the pumice is more or less porous; and the lowermost part of the bed is generally completely compact and passes into the state of a dense glass. In some specimens the complete transition from the one to the other state may be traced by very delicate gradations.

There appears to be the same relation between compact and porous pumice that there is between compact and porous lava; the inferior part of a bed of lava being always compact; the superior, porous.

Most of the pumice of commerce comes from the island of Lipari. It is used in polishing various substances.

INDEX.

A

acanticon i. 242
actinolite i. 116
actinolite, glassy i. 242
—— shorlaceous i. 116
adamas ii. 31
adamantine spar i. 153
adularia i. 158
ætites ii. 181
agalmatolite i. 181
agaric mineral i. 38
agate i. 222
—— fortification agate i. 224
alabaster i. 15. 46. 62. 119
—— onyx i. 16
—— etymology of i. 63
alabastrites i. 219
alum ii. 13
—— rock alum ii. 13
—— Roman ii. 13. 16
—— capillary ii. 18
—— plumose ii. 18
—— incrustations of i. 42
alumine i. 135
—— native
—— sulphate of ii. 13
aluminous shale i. 189
alluvion, meaning of the term int. iv
amalgam ii. 80. 94
amber ii. 36
—— black ii. 49
amethyst, common i. 209
—— oriental i. 140
amianthus i. 100
ammonia, muriate of ii. 12
amygdaloid i. 248. app. 19
anhydrous sulphate of lime i. 72
antimony ii. 200
—— plumose ore of ii. 201
—— red ore of ii. 202
—— sulphuret of ii. 201
apatite i. 80
aquamarine i. 128
—— shorl i. 243

INDEX.

arendalite i. 242
argentine felspar i. 159
argill i. 135
armenian bole i. 179
armenian stone ii. 118
arragon spar i. 55
arrow stone i. 116
arsenic ii. 203
—— sulphuret of ii. 205
—— how detected ii. 70
asbestus i. 100
—— ligniform i. 105
asbestinite i. 116
asphaltum ii. 63
asparagus stone i. 80
asteria i. 137. 230
auripigmentum ii. 206
aurum graphicum ii. 218
—— paradoxum ii. 218
—— problematicum ii. 218
aventurine i. 203
automolite ii. 196
axe-stone i. 110
axinite i. 240

B

balass ruby i. 143
bar stone i. 89
baroselenite i. 88
baryt i. 86
—— carbonate of i. 37
—— sulphate of i. 87
basalt app. 6
—— fusion of app. 11
basaltine i. 238
basanite i. 215
bath stone i. 20
bellaria Tiburtina i. 28
beilstein i. 110
beryll i. 128
bildstein i. 181
bismuth ii. 212
—— ochre ii. 212
bitter spar i. 57
bitumen ii. 60
—— elastic ii. 64
bituminons shale i. 189
black marble i. 14
black crayon i. 190
black chalk i. 190
black lead ii. 58
black wad ii. 215
blende ii. 196
— origin of the term i. 239
blood stone i. 210
blue john i. 76
board coal ii. 47
bole i. 179
bologna stone i. 89
boracite i. 118
borax ii. 10
boulder stones app. 29
bovey coal ii. 45
brass, ore of ii. 195
breccia i. 9
— origin of the term i. 9
brocatello i. 10
brown spar i. 56
burnishing stones ii. 174

INDEX.

C

cacholong i. 225

cadmia ii. 193

cairngorum i. 198

calcareous spar, its constituent parts i. 2

—— dog tooth i. 52

—— nailheaded i. 54

—— primitive i. 51

—— primitive form of i. 50

—— veins of i. 58

calcedony i. 217

calamine ii. 193

camehuia i. 219

cameo i. 219

caoutchonc ii. 64

carbunculus i. 147

carnelian i. 219. 226

carbo fossilis ii. 51

carbon ii. 32

cat's eye i. 66. 222. 229

cawk i. 87

celestine i. 84

chalcanthum ii. 20

chalk i. 18

—— black i. 190

—— French i. 109

—— red ii. 174

chert i. 215

chlorite i. 114

chlorophane i. 75

chrome ii. 217

chrysoberyll i. 128

chrysocolla ii. 11. 119

chrysolite i. 120

—— basaltic i. 122

chrysolite, oriental i. 140

—— Vesuvian i. 252

chrysoprase i. 204

—— of the ancients i. 129

cimolian earth i. 18

cinnabar ii. 94

clay, brick i. 171

—— constituent parts of i. 33

—— fat and meagre i. 173, 4

—— observations on i. 173

clay, pipe i. 168

—— porcelain i. 165

—— potters' i. 169

—— stourbridge i. 170

clinkstone app. 18

coal ii. 51

—— cannel ii. 52

—— Newcastle ii. 55

—— observations on ii. 56

—— production of ii. 42

cobalt ii. 209

—— arseniate of ii. 209

—— flowers of ii. 211

—— peach blossom ore of ii. 211

—— red ore of ii. 211

cockle i. 238

compass rock app. 10

copper ii. 98

—— of cementation ii. 100

—— arseniate of ii. 89

—— carbonate of ii. 117

—— blue carbonate of ii. 117

copper, green carbonate of ii. 119
—— grey ore of ii. 115
—— muriate of - - - ii. 106
—— native ii. 98
—— phosphate of ii. 127
—— pitch ore of ii. 105
—— purple ore of ii. 108
—— pyrites ii. 109
—— red oxyd of ii. 101
—— sulphate of ii. 23
—— sulphuret of ii. 105. 109
—— vitreous ore of ii. 106
—— yellow ore of ii. 109
copperas, blue ii. 20
—— green ii. 23
—— white ii. 24
corundum i. 153
craie de Briançon i. 109
crayon, black i. 190
—— red i. 180
creta i. 18
—— Cimolia i. 175
—— Hispanica i. 98
crystal i. 195
crystal, origin of the term int. xxxiv
crystals, primitive form of int. xxxvi
—— pseudomorphic xxxviii
—— secondary xxxviii
cube spar i. 72
cubic quartz i. 118
culm ii. 56
cyanite i. 182

D

Derbyshire spar i. 73
diamond i. 8
dolomite ii. 31

E

Egyptian jasper i. 208
electricity of minerals int. xxxii
electrum ii. 96
emerald i. 130
—— oriental i. 140
euclase i. 133

F

fahlertz ii. 115
felspar i. 157
—— blue i. 160
—— compact laminated - —
—— earthy i. 162
—— green i. 159
—— opaline i. 160
—— observations on i. 161
ferrilite app. 15
flint i. 211
flos æris ii. 20
—— ferri i. 44
fluor i. 73
—— blue i. 76
—— colourless i. 74
—— corroded crystals of i. 78
—— earthy
—— green i. 77
—— purple i. 75
—— yellow i. 77

free-stone i. 20
—— calcareous i. 20
—— siliceous app. 26
fullers' earth i. 175
fusibity of minerals int. xxxi

G

gagates ii. 49
galena ii. 130
—— silver contained in it ii. 133
garnet i. 147
—— Bohemian i. 148
—— oriental i. 150
—— Sirianic i. 148
—— white i. 254
gemma Turcica ii. 190
geodes ii. 181
glacies Mariæ i. 66. 183
glucine i. 128
gold ii. 75
—— cuppellation of ii. 81
—— sand ii. 77
—— white ore of ii. 218
granatus i. 147
granite app. 1
—— disintegration of i. 164. app. 32
—— graphique app. 3
granitelle app. 20
graphite ii. 58
grauwacke app. 23
greenstone app. 21
grenatite i. 254
gritstone app. 24
grünstein app. 21

gypsum i. 60
—— farinaceous i. 65
—— fibrous — —
—— *glaciale* i. 66
—— granular i. 62
—— of Montmartre i. 61
—— *speculare* i. 66
—— observations on i. 69

H

hammites i. 26
hardness of minerals int. xxxii.
heliotropium i. 210
Helmontii, ludus i. 35
hematite ii. 171
hone-stone i. 216
honey-stone ii. 39
hornblende i. 238
———— basaltic ——
———— colour of app. 10
———— schistose app. 9
hornstone, whence the term app. 18
hyacinth i. 126
—— brown volcanic i. 252
—— of Compostella i. 202
—— white cruciform i. 251
hydrargillite i. 136

I

Iceland agate app. 38
—— crystal i. 52
—— spar —
igida i. 110
inflammable substances ii. 27
iridescence, causes of i. 52. 60. 106

iron ii. 156
—— argillaceous ores ii. 178
—— arseniate of ii. 192
—— ball ore ii. 181
—— carburet of ii. 58
—— cast ii. 178
—— cold short ii. 183
—— Elba ore ii. 169
—— glimmer ii. 170
—— hematitic ores ii. 171-176
—— lowland ore ii. 182
—— magnetic ore ii. 165
—— meadow ore ii. 182
—— micaceous ore ii. 170
—— morass ore ii. 182
—— native ii. 156
—— native oxyd of ii. 165
—— pea ore ii. 181
—— phosphate of ii. 190
—— pig ii. 178
—— pyrites ii. 184
—— red oxyd of ii. 171
—— red scaly ore ii. 175
—— red short ii. 167
—— slag ii. 175
—— sparry ore i. 56. ii. 188
—— specular ore ii. 168
—— steel ore ii. 189
—— sulphate of ii. 20
—— sulphuret of ii. 184
—— swamp ore ii. 182

J

jade i. 110
jargon i. 125
jasp-agate i. 224
jasper i. 206
—— crystallized i. 202
—— Egyptian i. 208
—— ribband i. 207
—— wood i. 209
jet ii. 49

K

kaolin i. 164
killas i. 188
kragg app. 19
kupfer-nickel ii. 213

L

labradore stone i. 160
lac lunæ i. 38
lait de montagne ——
lapis lazuli i. 244
—— Lydius i. 215
—— nephriticus i. 113
—— ollaris i. 95
—— Siphnius i. 95
lava app. 31
lead ii. 129
—— carbonate of ii. 136
—— cromate of ii. 143
—— glassy ore ii. 136
—— green ore ii. 141
—— molybdate of ii. 139
—— muriate of ii. 145
—— native ii. 129
—— native oxyd of ——
—— native vitriol of ii. 140
—— ochre ii. 138

lead phosphate of ii. 141
—— potters' ore ii. 130
—— red, of Siberia ii. 143
—— sparry ore ii. 136
—— steel grained ore ii. 133
—— sulphate of ii. 140
—— sulphuret of ii. 130
—— white ore ii. 136
—— yellow ore ii. 139
lepidolite i. 246
leucite i. 254
leucostictos app. 5
lilalite i. 246
lime i. 1
lime, anhydrous sulphate of i. 72
lime, arseniate of i. 81
lime, carbonate of i. 2. 37. 50
lime, fluate of i. 73
lime, native i. 1
lime, phosphate of i. 78
lime, sulphate of i. 59
limestone i. 3. 18
—— blue i. 30
—— grey & black i. 29
—— hardens by exposure i. 22
—— magnesian i. 23
—— use of, in metallurgy ii. 175
lithanthrax ii. 51
litharge ii. 133
lithomarga i. 177
loam i. 172
ludus Helmontii i. 35
lumachella i. 16
lychnites i.

M

macle ii. 151
magnesia i. 91
magnet, native ii. 165
malachite ii. 119
maltha ii. 62
mandelstein app. 19
manganese ii. 214
—— colours carbonate of lime i. 17. 32
—— native oxyd of ii. 214
—— rose coloured ore ii. 215
marble i. 3
marble, black i. 14
marble, black and white i. 14
marble, brecciated i. 9
marble, brocatello i. 10
marble, Carrara i. 5
marble, cipolino i. 6
marble, Cottam i. 17
marble, Dolomite i. 8
marble, elastic i. 8
marble, Florentine i. 17
marble, lumachella i. 16
marble, nero antico i. 14
marble, Parian i. 4
marble, primitive i. 4
marble, rouge antique i. 13
marble, serpentine i. 15. 94
marble, shell i. 16

marble, stalagmitical i. 15
marble, Tiree i. 15
marble, vert antique i. 11
marble, white granular i. 7
marcasite ii. 184
marl i. 32
marmor Lacedæmonium i. 13
—— Lunense i. 6
matrix of a mineral int. xxxix
meconites i. 26
meerschaum i. 99
melanteria ii. 22
mellilite ii. 39
menachanite ii. 224
menilite i. 232
mercury, native ii. 93
metals ii. 69
—— alloys of
—— native
—— ores of ii. 70
—— oxyds of ii. 69
—— salts of ii. 69, 70
—— sulphuret of
mica i. 183
minerals, electricity of int. xxxii
minerals, fusibility of xxxi
—— hardness of xxxii
—— phosphorescence of xxxii
—— refractive power of xxxiii
—— specific gravity——
minium ii. 94
mispickel ii. 203
mocoa stone i. 225
molecule, integrant int. xxxvii
molybdena ii. 216
moon stone i. 67. 158
mountain blue ii. 117
—— green ii. 119. 124
mullen app. 19
muriacite i. 72
muricalcite i. 57

N

naphtha ii. 61
natron ii. 4
nephrite i. 113
nero antico i. 14
nero è bianco antico ——
nickel ii. 213
—— alloyed with arsenic
—— alloyed with iron ii. 158
—— native oxyd of ii. 213
nitre ii. 3
novaculite i. 216

O

obsidian app. 38
ochre i. 177
—— brown i. 180
—— red i. 178
—— yellow i. 178
olivin i. 122
onyx i. 219
—— stratified i. 220
oolithus i. 26
opal i. 227
—— hydrophanous i. 230

INDEX.

opalus ii. 13
ophites app. 6
ores, metallic ii. 70
—— roasting of ii. 112
orpiment, native ii. 205
osteocolla i. 42

P

pæderos ii. 31
peach i. 114
peat ii. 43
pearl spar i. 56
—— stone app. 38
pebbles, cause of their form int. iv.
——— siliceous app. 28
pebblestone app. 21
pechblende ii. 220
peridot i. 120
petrifactions i. 37, 41
petroleum ii. 62
petrosilex i. 215, 222
petuntzé i. 164
pharmacolite i. 81
phengites i. 6
phospholite i. 78
piligno ii. 45
pipe clay i. 168
piperino i. 26
pisolithus i. 27
pitch, cohesive mineral ii. 62
—— Jews' ii. 63
pitch-stone i. 231
plasma i. 205
plaster of Paris i. 62
platina ii. 73
plumbago ii. 58
plumb-pudding stone app. 21
porcelain clay i. 165
porphry app. 5
portland stone i. 21
potstone i. 95
potters' clay i. 169
prase i. 203
prehnite i. 250
Prussian blue, native ii. 190
pseudogalena ii. 196
pseudopal i. 229
pumice app. 35
puzzolana i. 26, 30. app. 34
pyrites arsenical ii. 203
—— auriferous 186
—— copper 109
—— martial 184
—— tin 154
pyropus i. 147

Q

quartz i. 192
—— amethystine i. 200
—— black transparent i. 198
—— blue i. 200
—— colourless 195
—— elastic app. 27
—— glassy i. 195
—— opaque red 202
—— paper 205
—— rose red 199
—— yellow 199
quicksilver ii. 93

INDEX.

quicksilver alloyed with silver ii. 94
———— horn ii. 97
———— muriate of ii. 97
———— sulphuret of ii. 94

R

ragg-stone app. 16
———— Rowley — —
realgar, native ii. 205
reddle i. 178
refractive power of minerals int. xxxiii
retinasphaltum ii. 66
rhomb-spar i. 57
ribband jasper i. 207
rock crystal i. 195
—— salt ii. 7
roe-stone i. 26
rotten-stone app. 31
rouge antique i. 13
rubellite i. 236
rubrica i. 178
ruby i. 139
—— Bohemian i. 199
—— Silesian i. 199

S

sal, ammoniac ii. 12
— gem ii. 7
saline substances ii. 1
———— alkaline ii. 3
———— earthy ii. 13
———— metallic ii. 20
salt, common ii. 7
salt, rock ii. 7
saltpetre ii. 3
sand of Ceylon i. 144
sandaraca ii. 205
sandstone app. 24
——— of Fontainbleau app. 27
——— micaceous app. 26
sappare i. 182
sapphire i. 137
——— mock i. 200
——— occidental i. 200
sard i. 227
sarda i. 226
sardion — —
sardonyx i. 219
satin spar i. 49
scheelium ii. 225
schistus i. 186
—— micaceous app. 5
selenite i. 60, 66
semi-opal i. 231
septarium i. 35
serpentine i. 93
——— marble i. 15, 94
——— noble i. 94
shale i. 33, 188
—— aluminous i. 189
shorl, aquamarine i. 243
—— black i. 233
—— electric i. 233
—— "en masse" app. 9
—— glassy i. 240
—— green i. 242
—— opaque rhomboidal i. 239

INDEX.

shorl, red ii. 222
—— red, of Siberia i. 236
—— violet i. 240
—— white i. 158. ii. 223
sidero-calcite i. 56
sienite app. 20
silver ii. 83
—— antimoniated ii. 85
—— —— sulphuret ii. 89
—— arsenico martial ore ii. 86
—— black ore ii. 90
—— brittle vitreous ore ii. 91
—— grey ii. 116
—— horn ii. 91
—— mulm ii. 90
—— muriate of ii. 91
—— native ii. 83
—— sulphuret of ii. 87
—— virgin ii. 83
—— vitreous ore ii. 87
—— white ii. 116
sinople i. 208
slag ii. 175
slate i. 186
—— calcareous i. 31
—— roofing i. 187
slickensides ii. 134
smaragdus i. 130
soapstone i. 96
soda, borate of ii. 10
—— carbonate of ii. 4
—— muriate of ii. 7
sory ii. 22
spar, double refracting i. 52
spar, heavy i. 88
—— pearl i. 56
—— rhomb i. 57
spargelstein i. 80
specific gravity of minerals int. xxxiii
spinell ruby i. 143
stalactites i. 37. 43
—— observations on i. 46
stalactitic incrustations i. 41
stalagmite i. 44
—— greenish white i. 46
stangenspath i. 89
staurolite i. 251
steatite i. 96
stibium ii. 201
stone coal ii. 51
stones meteoric ii. 159
Stourbridge clay i. 170
strata int. ii.
strata, primitive — —
strata, secondary — —
strahlstein i. 82
strontian i. 82
strontian, carbonate of — —
strontian, sulphate of i. 84
succinum ii. 36
sulphur ii. 30. 70. 114
surturbrand ii. 45
swimming stone i. 205
swinestone i. 29

T

talc i. 106
talc, indurated i. 109
talc, laminated i. 107
talc, silvery i. 91. 107
talc, Venetian i. 108

INDEX.

tar, mineral ii. 62
tellurium ii. 218
terra Lemnia i. 178
terra sigillata i. 178
terras app. 35
thallite i. 242
thumerstone i. 240
tin, native ii. 146
tin, analysis of tinstone ii. 151
tin, native oxyd of ii. 147
tin pyrites ii. 154
tin, resin ii. 152
tin, shot ii. 149
tin, stone ii. 147. 149
tin, stream ii. 148
tin stream works ii. 147
tin, sulphuret of ii. 154
tin, wood ii. 149
tinkal ii. 10
titanite ii. 222
titanite, red i. 198
titanium ii. 222
——— native oxyd of ii. 222
Tivoli, calcareous concretions of i. 28. 65
toadstone app. 19
topaz i. 145
—— Bohemian i. 199
—— Brasilian i. 146
—— mock i. 199
—— occidental i. 199
—— oriental i. 140
—— Saxon i. 147
—— Siberian i. 147
tophus i. 24
—— calcareous i. 24. 37
touchstone i. 215
tourmaline i. 233
trapp app. 18
trass app. 35
travertino i. 25
tripoli app. 31
tufa i. 24
tungsten ii. 225
turf ii. 43
turquoise ii. 190

U

ultramarine i. 245
umber i. 180
uranium ii. 220
uranite, micaceous ii. 221

V

veins, mineral int. ix
—— calcareous i. 58
—— in limestones i. 35, 36
—— in marble i. 7
verde di prato i. 94
—— di Susa — —
vert antique i. 11
Vesuvian i. 252
vitriol, blue ii. 23
—— of copper — —
—— green ii. 20
—— of iron — —
—— white ii 24
volcanic glass app. 38

W

wacke app. 19
—— grey — 23
wavellite i. 136
whetstone app. 26

INDEX.

whin-dyke app. 14
—— stone app. 2. 7
whiting, prepared from chalk i. 20
witherite i. 86
wolfram ii. 226
wood jasper i. 209

Z

zeolite i. 247
—— cubic i. 248
zeolites greenish i. 250
zinc ii. 193
—— carbonate of ii. 198
—— native oxyd of ii. 193
—— oxyd of colours carbonate of lime i. 46, 54
—— sulphate of ii. 24
—— sulphuret of ii. 196
zircone i. 124
zircon of Ceylon i. 125

FINIS.

Errata in Vol. 1.

Pag. 32. lin. 8. for “its nature,” read “the nature of the colouring substance.”

Pag. 51. lin. 18. for “$101^d\ 30'$ and $78^d\ 30'$,” read “$101^d\ 32'$ and $78^d\ 28'$.”

Pag. 52. lin. 5. for “which is not a natural variety,” read “which is an accidental form of a natural variety.”

Pag. 74. lin. 10. for “it does not,” read “this property does not.”

Pag. 88. lin. 12. for “almost,” read “exactly.”

Pag. 184. lin. 26. for “tenacity,” read “tenuity.”

Pag. 221. lin. 21. for “the eyes of different animals,” read “eyes of different colours.”

Errata in Vol. 2.

Pag. 23. lin. 21. for “Sulphate of iron,” read “Sulphuret of iron.”

Pag. 35. lin. 5. for “those substances acquire,” read “those substances when unpolished acquire.”

Pag. 46. lin. 3. for “legnite,” read “lignite.”

Pag. 79. lin. 21. for “Sulphurets of Copper,” read “Metallic Sulphurets.”

Pag. 98. lin. 22. for “in the eastern extremity,” read “at the eastern base.”

Errata in Appendix.

Pag. 37. lin. 2. for “Sève,” read “Sèvres.”